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November 2000
Vol. 21 No. 11

Exploring Electronics And Technology For A New Millennium

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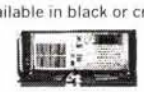

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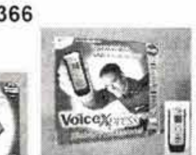
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Lots of details on Pages 48-49!!


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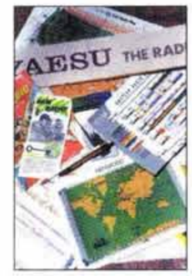

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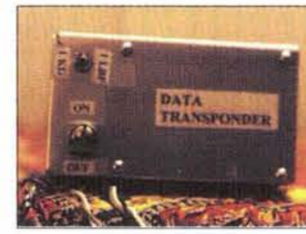

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Holiday Project

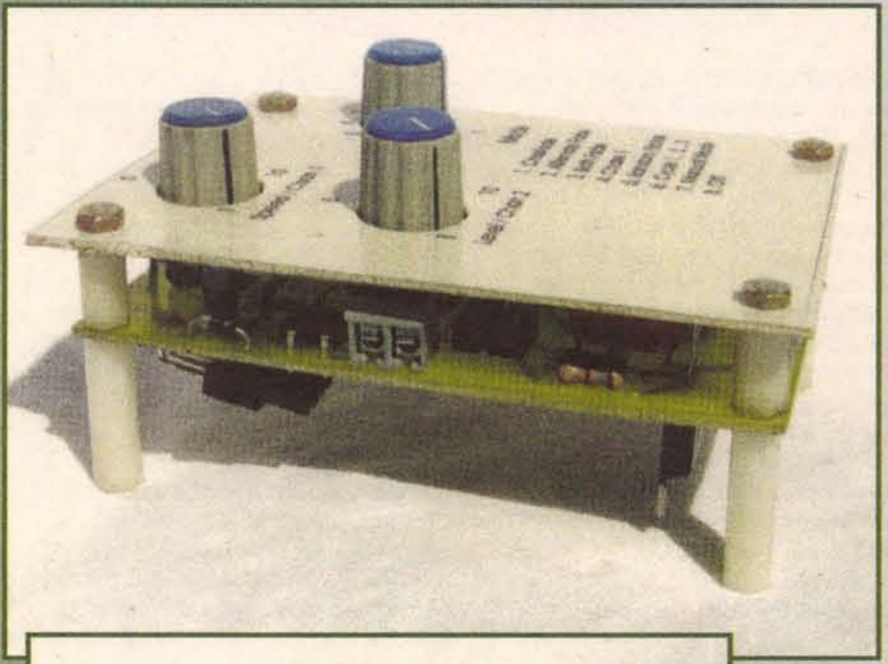
by James A. Cart

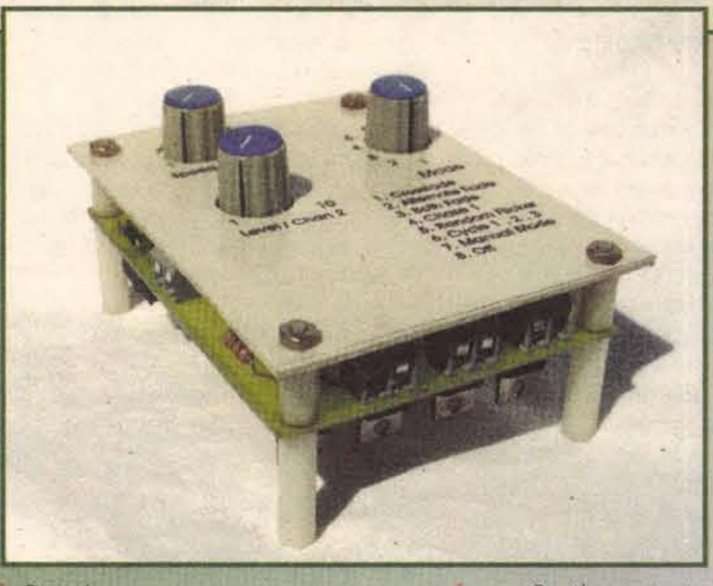
Holiday Lighting Dimmer

With the holidays approaching, lighting displays will begin to appear in homes all across the country. With the proliferation of on/off blinking light strings, I decided it was time to build a dimming display controller.

This article details the programming and circuit necessary to build a four-output (channel), microcontroller lighting dimmer. Software provides three preprogrammed crossfading chases, three on-off chases, a random flicker effect, and manual control. This is great for fading holiday light displays or would-be DJs.

First, we'll discuss the basic operation of a light dimmer. Next, we'll look at the hardware interface to the microcontroller. This will help to explain the requirements of the software. Finally — the fun part — construction.





PC BOARD AND COVER PLATE STACK.

This project was built using the Atmel 89c2051. This micro is a 20-pin version of that old war-horse, the Intel 8031. The software for this project will run on the 8031-1 without modification.

AC Phase Control

Some phase control basics of triac-based lighting dimmers should be covered to help explain the hardware and software.

In order to vary the brightness of a lamp, the triac is turned on for only a portion of the AC cycle. By controlling when the triac is fired during each AC half cycle, the average power to the lamp can be varied, and thus the brightness. For a microprocessor, this is a trivial task. Simply determine when the AC zero crossing point is reached. This is the beginning of the half cycle.

At this point, it is a matter of delaying the firing of the triac until the proper time. If the delay time is long, the triac will be on for a small portion of the cycle and the lamp will be dim. As the delay becomes shorter, the on time will be longer and the lamp will be brighter. This process is repeated every half cycle.

Hardware

As you can see from the schematic, there isn't much to it. Which is really the main point of using a microcontroller. Do the work with software and minimize the hardware.

First, I'll cover the inputs to the micro, then the outputs.

The output from the 12-volt transformer is full wave rectified by diode bridge D0. This creates a pulsing DC output. The 1N4001 diode is used to separate these pulses from filter cap C1.

Transistors Q1 and Q2, along with resistors R0-R4, are used to derive a pulse around the zero crossing point. This signal is fed to the external interrupt pin on the microcontroller.

The chase pattern is selected with a binary coded decimal (BCD) switch, S1. The BCD switch is connected to the upper four pins of Port 1.

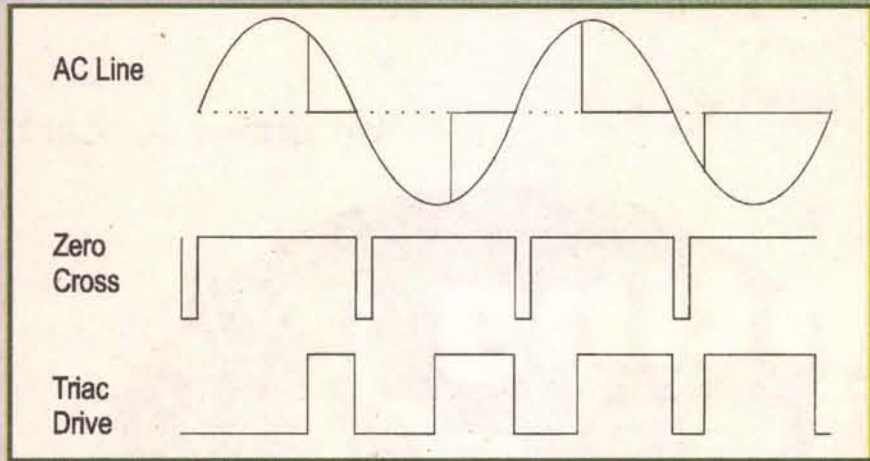
To read the control pots, I selected a serial analog-to-digital converter (ADC) for several reasons. They are cheap and compact. The ADC08032CIN has two inputs but uses only eight pins, requiring three pins for serial communication to the microcontroller. The Vref is internally tied to the five-volt supply. If one wanted eight analog inputs, an ADC0848 serial ADC could be used, still requiring the same three pins and a little extra software.

On the output side, we'll be using the lower four pins of port 1, to fire the MOC3010 triac drivers. Since these pins can sink 20 milliamps each, they can drive the optoisolators directly.

On the high voltage side of the opto's is a standard configuration for triac light dimmers. A common 7805 provides voltage regulation.

Programming Language of Choice

Assembly language is required



TIMING DIAGRAM. Demonstrates relationship between AC sinewave, zero crossing pulse, and TRIAC drive signal.

for the 8031 to execute the necessary instructions in the allotted time. This is a real-time process. The software must be able to "keep up" with the AC line. If the program execution is slow or inconsistent, then smooth dimming will not be achieved. This project makes use of two of the six interrupts available on 8031.

Some versions of BASIC have instructions such as "On Interrupt" that do allow the use of interrupts. However, the program overhead associated with high level languages may eat up too much time for this application.

There is also the "C" language, but assembly compilers are free.

Welcome Interruption

What is an interrupt anyway? In a nutshell, interrupts force the processor to stop what it is doing and jump to a reserved location in program memory called the interrupt vector. The microcontroller will then execute code at the vector location, called the Interrupt Service Routine (ISR).

When the ISR is complete, the microcontroller will return to where it was and resume what it was doing. This interruption of normal program flow can be very useful when time-critical events need immediate attention by the microcontroller. Interrupts can be generated by external hardware or internal interrupts can be generated by timers or serial UART onboard the microcontroller. Timer interrupts are useful when the microcontroller needs to execute a task at a specific time interval. Timer interrupts can be used for pulse modulation on motor controls, to time the pulse for servo controls or, in this case, to time the delay for our dim levels.

The beauty of interrupts is that, when properly written, they are transparent to the main program loop. There are a few caveats when using interrupts. Generally, ISRs are kept as short as possible. One must be careful not to change any registers, flags, or variables in a way unexpected by the main program loop. This can cause seemingly random bugs in program execution. Registers and variables can be "borrowed" by the ISR, but must be restored to their previous values before exiting the ISR.

Manufacturers deal with interrupts in slightly different ways. On the 8031, each of six possible interrupt sources vector to different reserved locations in program memory. With midrange PIC microcontrollers, both external and internal interrupts vector to the same reserved location. It is up to the software to sort out which has occurred.

I have just hit the highlights for using interrupts. Getting the manufacturers data book or a book specific to the microcontroller is pretty much required if you are not familiar with a particular micro.

Zero Crossing Interrupt

The heart of this software is in the interrupts. This is the part of the code that actually does the "dimming." See Listing 1.

Here is what happens. Hardware triggers the external interrupt on the 8031 at the AC zero crossing point. Immediately, program execution vectors to the ISR. The first thing this routine does is save the important registers also used by the main program loop.

Next, the current dim levels are moved to variables chan1temp — chan4temp for the next half cycle.

Next, the ADC subroutine is called to read the potentiometers. The reason the ADC routine is called during the zero crossing is that this is the only time when it's guaranteed the timer won't

```
;==================================================================
Inter0:            ;EXTERNAL INTERRUPT FOR ZERO CROSS
        clr tr0                          ;stop dim timer
        mov asave, a                     ;save accumulator
        mov psw_save, psw                ;save program status word
        anl p1, #11110000b               ;turn off triacs - p1.0 - p1.3

  mov chan1temp, chan1                   ;reload dim level
  xrl chan1temp, #11111111b              ;invert because of hardware
  mov chan2temp, chan2
  xrl chan2temp, #11111111b
  mov chan3temp, chan3
  xrl chan3temp, #11111111b
  mov chan4temp, chan4
  xrl chan4temp, #11111111b

        call getlev                      ;call subroutine for serial ADC
zcwait:
        jb p3.2, zc_done                 ;wait here for end of zero cross
        sjmp zcwait
zc_done:
        mov psw, psw_save                ;restore psw
        mov a, asave                     ;restore acc
        setb tr0                         ;start dim timer
        reti
;==================================================================
```

LISTING 1

```
;==================================================================
timer0: ;timer0 interrupt, dim level
ch1:  djnz chan1temp, ch2                ;count down until level reached
   setb p1.0                             ;turn on triac
ch2:  djnz chan2temp, ch3                ;do next
   setb p1.1
ch3:  djnz chan3temp, ch4
   setb p1.2
ch4:  djnz chan4temp, t_done
   setb p1.3
t_done:  reti                            ;return from interrupt
;==================================================================
Fine Details
 Below is the code required to set up the interrupt vectors.
;==================================================================
org 00h                   ;start at loc 0
 ljmp init0               ;jump around interrupt vectors at startup
org 03h                   ;external interrupt 0
 ajmp inter0              ;jump to ISR
org 0bh                   ;timer 0 interrupt
 ajmp timer0              ;timer 0 ISR
org 013h                  ;external interrupt 1
        reti              ;not used
org 01bh                  ;timer 1 interrupt vector
        reti              ;not used
org 023h                  ;serial int. vec loc
  reti                    ;not used
org 02bh                  ;
        reti              ;not used
;==================================================================
To use the timers and interrupts, they must be setup and
enabled.==========================================================
========
 MOV tmod, #00010010b          ;timer1 = 16 BIT/ TIMER0 = auto reload
;— SETUP EXTERNAL INTERRUPT FOR ZERO CROSS ———
 setb ex0              ;int 0 enabled
 setb it0              ;make edge sensitive
;—— SETUP DIM TIMER ————
 mov th0, #0215d          ;dim timer reload value for 255 levels
 setb et0                 ;enable timer0 interrupt
 setb pt0                 ;priority timer 0
 setb tr0                 ;start timer
 setb ea                  ;enable all interrupts
;==================================================================
```

LISTING 2

```
;==================================================================
        mov a, p1                 ;get switch from port
  anl a, #11110000b               ;mask lower 4 bits(triacs)
  xrl a, #11110000b               ;invert upper 4 bits
        swap a                    ;swap nibbles
        mov switch, a             ;store in variable
;==================================================================
```

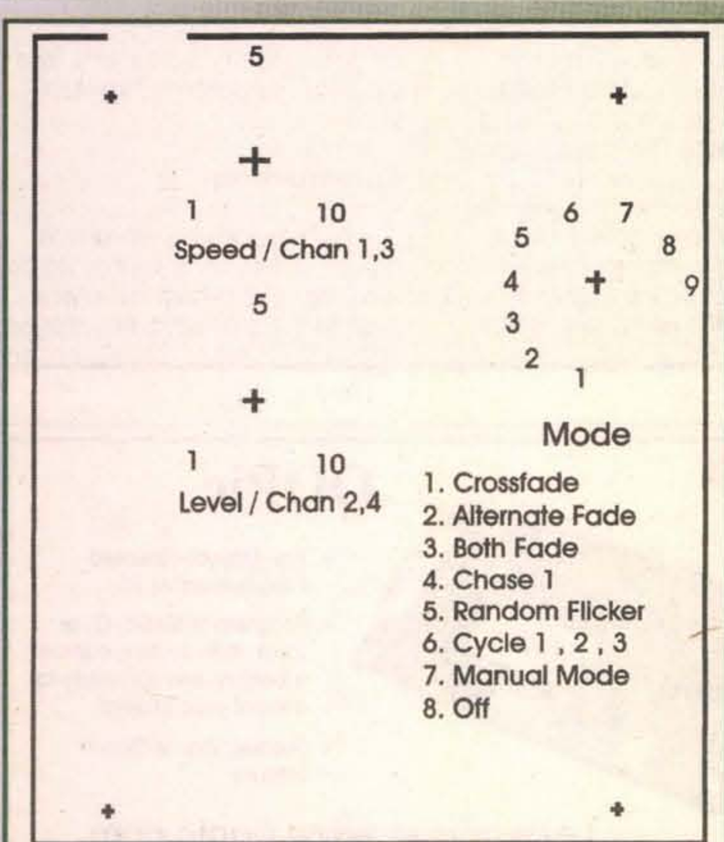
LISTING 3

```
;========================================================================
xfade: ;4 channel
jb xfadeflag, xf_down                    ;jump to fade down on flag
xf_chk:
mov a, chan1                             ;get channel 1 level
        inc a                            ;check for rollover
        jnz xf_up                        ;
  setb xfadeflag                         ;set flag on rollover
        ajmp xf_down                     ;/jump to fade down
xf_up:                                   ;\else fade up
  inc chan1                              ;fade up chan 1-3
        inc chan3
        mov a, chan1                     ;
  xrl a, #0ffh                           ;invert chan 1
        mov chan2, a                     ;fade down chan 2-4
        mov chan4, a
        ajmp main1                       ;exit loop
xf_down:
        mov a, chan1                     ;check for 0
        dec a                            ;
        jnz xf_d1                        ;loop if not zero yet
  clr xfadeflag                          ;clear flag on rollover
        ajmp main1
xf_d1:
  dec chan1                              ;fade down chan 1-3
        dec chan3                        ;
        mov a, chan1                     ;
  xrl a, #0ffh                           ;invert chan 1
        mov chan2, a                     ;fade up chan 2-4
        mov chan4, a                     ;
  ajmp main1                             ;exit
;========================================================================
```

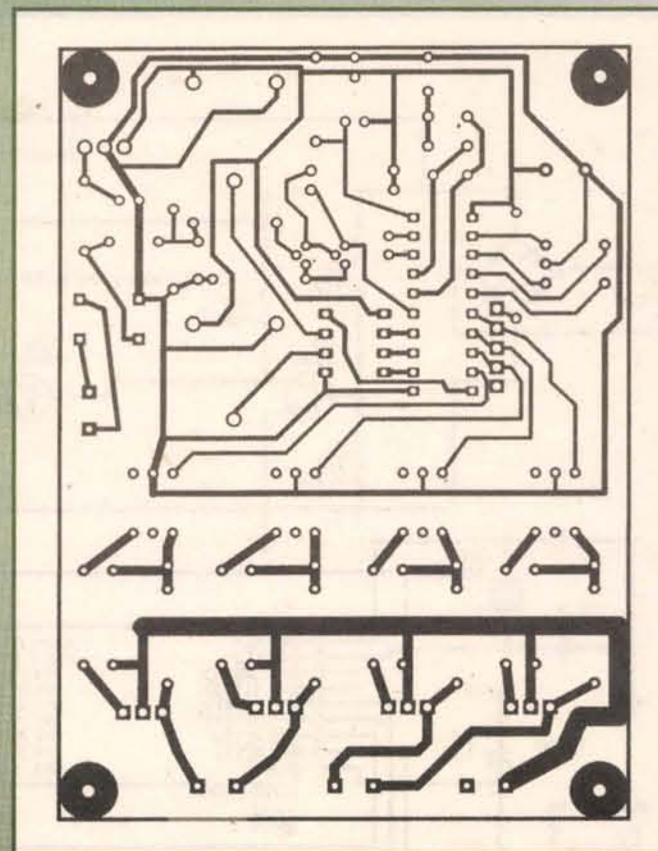
LISTING 4

```
;========================================================================
delay_s:  ;time delay for speed
          mov delay2, speed        ;load speed pot value for outer loop
d1:       djnz delay1, d1          ;stall here while delay1 is counted down
          mov delay1, #0200d       ;load delay value for next(inner) loop
d2:       djnz delay2, d1          ;count down delay2(outer) and loop again
          ret                      ;return from delay
;========================================================================
```

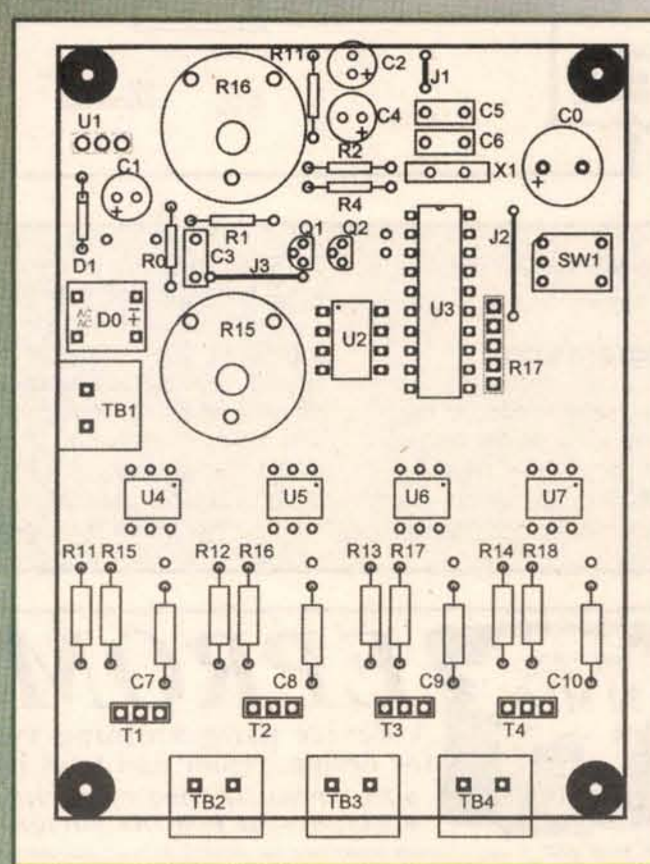
LISTING 5



FRONT PANEL LABEL.



PC BOARD PATTERN.



PARTS PLACEMENT.

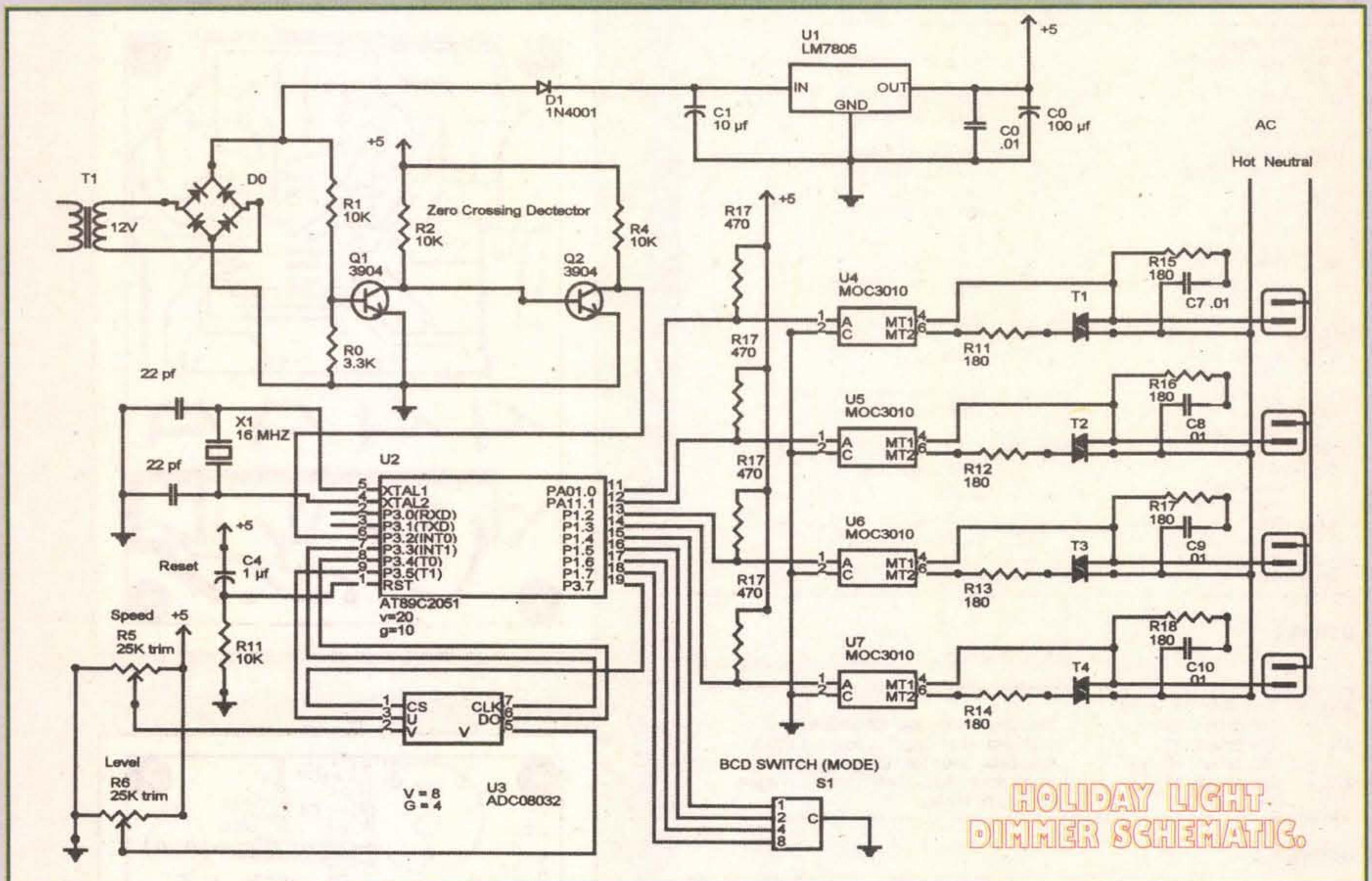
"interrupt."

Before exiting, the saved registers are restored.

Timer 0

Since the triac is only on for a portion of the half cycle, there must be a way to determine how much time has passed since the zero crossing point. That is the job of the timer interrupt. Each time this routine is executed, all four dim levels are decremented. When each dim level reaches zero, its corresponding port pin is made high and the triac turns on.

We want smooth fades, so there are 255 dimming levels. Therefore, the timer routine must execute 255 times every half cycle. That is only 32 microseconds between interrupts, including the execution time for the interrupt itself. In the code in Listing 2, only two instructions are used. Neither instruction affects the accumulator



HOLIDAY LIGHT DIMMER SCHEMATIC.

or other registers so they are not saved.

Main Program Loop

There are several jobs for the main program loop. At the beginning of each loop, the software checks the BCD mode switch. The current position is stored in variable SWITCH. The code below returns a value from 0-9. See Listing 3.

Next, the main loop jumps to a subroutine selected by the mode switch. The selected subroutine determines the current dim level and stores this value in variables chan1-chan4. Listing 4 is an example of a basic crossfade.

The last job of the main loop is to create a time delay between chase steps. The code in Listing 5 is a type of delay with an inner and outer loop. This is just a simple time waster.

None of the main loop functions are particularly time critical. There is no attempt to equalize the lengths of the various subroutine calls. No one is going to notice if the total delay is inconsistent by a couple of milliseconds between steps.

Construction

With a careful building technique, point-to-point wiring can be used. Be sure to keep the crystal close to the processor. And, please,

be careful when making connections to the 120-volt side. Bad solders or loose wires are intolerable for line side connections. If you chose to make your own printed circuit board, everything fits nicely on a single sided board.

I have had good success with Kepro Presensitized boards. These do require a negative for exposure. I use transparency film for laser printers to print negatives. Of course, your software has to have an "invert" or "negative" function when printing. The density isn't as good as film, but if your exposure time is kept to a minimum, the results are just fine. I like to install the low profile parts first, resistors and jumpers. Then work up to the taller parts, mounting triacs last.

I installed the triacs and voltage regulator on the bottom (solder side) of the board, because they were too tall to fit under the label cover. Use triacs with insulated tabs for safety. If you plan on using 600 watts per triac or more, you must provide a heatsink.

I built mine into a standard weatherproof electrical junction (J) box. Most national home improvement stores carry them. The circuit board will fit in a 6" x 6" x 4" J box. Remove the two knock-outs at the bottom of the J box. Use threaded nipples to attach a cast aluminum, two gang, duplex receptacle box. A bead of silicone glue between the boxes won't hurt.

Normal household duplex receptacles have tabs connecting the top and bottom outlets. Remove the tab on the hot side so you'll end up with two separate outlets on each duplex receptacle. Be sure to spring for the weatherproof cover if you plan to use the dimmer outside.

PCB Sandwich

I mounted the cover plate and PC board in a double deck assembly. Use 1.5" nylon male/female standoffs to mount the circuit board in the J box. The male threads will protrude up through the PC board. On top of the board, use 1/2" long male/female standoffs to attach the cover plate. Of course, the cover has holes drilled for the knobs to poke through. For the cover material, I used a piece of circuit board I had left over from another project. It was painted white to provide the background color for the label.

The label is printed on clear film for laser printers. Laser toner is waterproof. Print the label backwards (mirror image). When it is glued down with spray glue, the toner will be on the glue side. You will have a nice, glossy, scratch proof label. If you have an inkjet printer, print the label on paper and protect it with clear laminating film available at most craft stores or a clear coat spray. Or, forget the label and use a "Sharpie® fine point marker." Sharpies have indelible ink. Don't skip the cover plate for safety reasons.

Wire it all up with 16 AWG PVC hookup wire. Standard THHN house wire is way too stiff to thread around in those boxes.

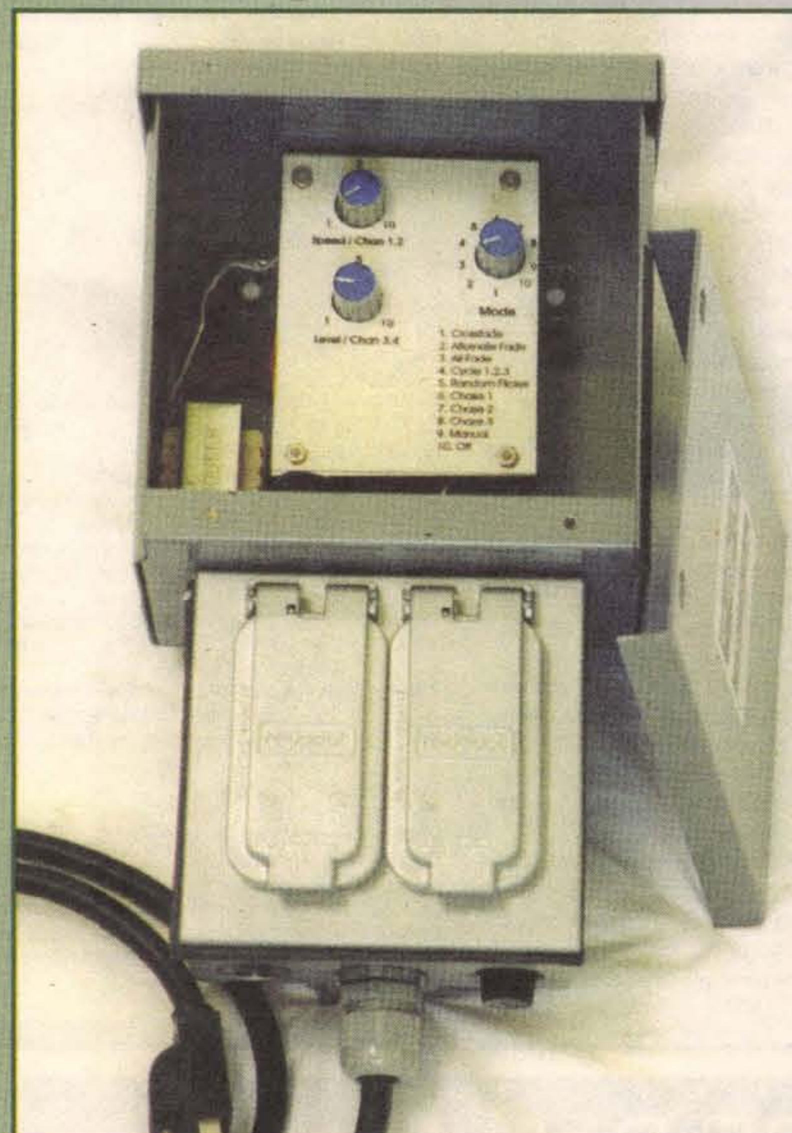
Don't forget to install a fuse holder for safety. I found that a 15-amp fuse holder fits in the threaded holes in the aluminum receptacle box.

On the *Nuts & Volts* website, you will find a .TIF file of the PC board, label, parts placement, and also a file with the compiled code.

Using the Holiday Light Dimmer

The speed pot is used to adjust the rate of fade in all modes as noted below.

The level pot is used for random flicker and manual modes.



FINISHED DIMMER.

Fading chase — Channel 1 fades up, then fades down. Channel 2 fades up, then fades down, and so on.

Crossfading chase — Channel 1 and 3 fade up, as channel 2 and 4 fade down. Then vise-versa, and so on.

Wave dimmer — All channels fade up then down in unison.

Cycle mode — This mode cycles through modes 1, 2, and 3. The fade pot is the same as before. The level pot is used to determine the duration of each mode before advancing to the next mode.

Random flicker — The speed pot is used to adjust the general speed of the flicker. The level pot is used to adjust the general bright-

ness of the flicker. It's actually brighter around the middle setting.

Chase – Simple sequential non-dim chase, one channel is on while the other three are off.

Chase 2 – Shimmy non-dim. Sequences back and forth. Three on, one off.

Chase 3 – Shimmy non-dim. Same as above except with one on, three off.

Manual mode – The speed pot controls the brightness of channels 1 and 2. The level pot controls the brightness of channels 3 and 4.

Off

A nice effect outdoors is to put different color strings of lights randomly in a tree, with each color plugged into a different output channel. A slow fading chase causes the tree to subtly change colors.

The random flicker is kind of cool when adjusted right. I prefer the slow end of the speed pot and the middle of the level pot.

When using your dimmer outside, mount it vertically in a dry place and away from potential vandals. Do something creative with your new dimmer and enjoy the Holidays! **NV**

Parts List

Parts fit example circuit board.

D0	Diode Bridge	Digi-Key part DB101MS-ND
D1	1N4001 Silicon Diode	
C0	350uF 16-volt electrolytic	
C1	10uF electrolytic	
C2	100 electrolytic	
C3	.01 ceramic disk	
C4	1 uF electrolytic	
C5,C6	22pF ceramic disk	
C7-C10	.01 Polypropolene, 250 volt	
R0	3.3K ¼ watt	
R1	10K ¼ watt	
R2	10K ¼ watt	
R4	10K ¼ watt	
R11-14	180 ½ watt	
R15-18	100 ½ watt	
R15-16	22K PC Mount trim	RadioShack.com 900-5940
R17	470 SIP resistor	Digi-Key part EXB-F6E471G-ND
Q1,Q2	2N3904 NPN	
U1	LM7805 Voltage regulator	
U2	ADC08032 Analog-to-digital converter	National Semiconductor
U3	AT89c2051 microcontroller	
U4-7	MOC3010 triac driver optoisolator	
T1-4	8 Amp triac, isolated tab, TO220	
Sw-1	Rotary dip BCD switch	Digi-Key part sw214-ND
TB1-4	Screw Terminal Block 5MM lead spacing	
X1	Xtal 16 MHZ low profile	Digi-Key 300-6034-ND
3 -	Knobs for trim pots	
	19mm shaft for trim pots	RadioShack.com 900-5964
4 -	.250" Hex male/female standoff .50" length	
4 -	.250" Hex male/female standoff 1.50" length	

Two-sided circuit board	$30.00
Parts kit, less micro	$28.00
Preprogrammed microcontroller	$10.00
Priority mail shipping	$ 4.50

Contact author at NorthlightSystems@att.net for payment and shipping details. Compiled code, front panel art,mounting template, and PC board pattern can be downloaded at: Http://northlightSystems.home.att.net/Holiday.htm or on the *Nuts & Volts* website at www.nutsvolts.com.

Coming next month in the December issue, is another Holiday Lighting project.

This project uses the Motorolla 68HC11, for those of you who are partial to that controller. But, since time is running short to build those Holiday Projects, we're doing a pre-release of the article on our website, just in case you want to get a jump on it before the December issue hits the street.

Check it out at **www.nutsvolts.com**

reader *FeedBack*

Response from Gordon West to last month's reader feedback comment:

Yowch! I certainly did slip a channel on the listing of over-the-air TV broadcasting. And no wonder I have never picked up any UHF TV signals beyond Channel 70 – all I hear is juicy phone stuff!

And yup, yowch, my wordprocessor – or maybe my fingers – left out a "1" to turn "around 15,000" into proper perspective. I don't think we want any direct broadcast satellites on 1,500 MHz, because then GPS users (1,575 MHz) might start seeing TV shows on their navigational screens.

Seriously Craig, thanks for the good catches, and I'll try to keep things straight on the next go-around.

Gordon West WB6NOA

Dear Nuts & Volts:

In my answer to Tech Forum #9004 about ferrite rod antennas, I made a mistake.

The example calculations in the book *Antennas* by John Kraus have two errors in them. His calculation of R_r on page 261 is too large (it should be 5.9e-9). His SNR calculation on page 262 uses the bad R_r value and fails to attenuate the background noise level by the radiation efficiency. The book is still good, but even good books have mistakes.

Another good book is E. C. Snelling's *Soft Ferrites* (1988), a frequently-cited, but out-of-print book. Due to the Tech Forum question, I asked my
library to find a copy, and we made an inter-library loan from the gracious US Air Force Technical Library at Edwards Air Force Base. That book is
the best reference I have seen, and it devotes a whole chapter (10 pages) to ferrite antennas.

Gerald Roylance
Mountain View, CA

Dear Nuts & Volts:

I wish to thank you for including us in your answer to the CB radio question in your magazine.

As an organization, we have been promoting the use of tube radios in the 11 meter radio band since 1986. We have helped locally here in Fresno, CA, to get Tube Radios back on the air.

Just a year or so ago, we started on the Internet and have been amazed at the response we have received from those that needed help in getting their radio back on the air. We have no banners or ads on the site. It is truly a labor of love. Someday, we hope to have enough support, at the least, to pay for itself.

I have been a subscriber to *Nuts and Volts* for several years, and continue to keep my subscription paid.

Some of the questions we get can't be answered, but I try to give the sender something to get them going. It depends on how much info they give for the desired question.

I am now a licensed amateur Ham-radio operator and we hope to include more info on Ham radios ... all in due time.

Again, thank you for your mention of us in *Nuts and Volts.*

Jim McBee KF6YLS
Founder of the
Old Tube Radio Network

Dear Nuts & Volts:

I just received my first issue of *Nuts and Volts*. The article by Fernando Garcia describing how to make an advanced launch controller for Estes rockets was great! I think that product would sell very well if it were in the form of a kit or, at least, if all the parts could be ordered together.

Brett Holmquist
via Internet

Dear Nuts & Volts:

Just wanted to thank you for the article on the Xylotron (Oct. 2000).

I maintain theatre pipe organs and have been looking for a circuit that would allow me to run chime and xylophone solenoids directly from the new electronic relays being used to replace original electro-pneumatic relays found on theatre organs.

The circuit the author used was directly adaptable for this purpose. I built a prototype of the relay this weekend and was able to operate a Barton crysoglot, which has 1.5 amp coils, directly from my Peterson multiplex relay.

Thanks again for publishing universally useful information.

John DeMajo
via internet

Dear Nuts & Volts:

In response to Kurt #2005 Feb. 2000.

I know exactly what you are looking for. It was called a 'Zapper Radar Activator'

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DISPLAY ADS
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and was available through 'The Edge Company' at 1-800-445-1021. It sold for about $29.00.

I bought one over three years ago, and it was a great tool on long trips, especially when some jerk in an Aston Martin, BMW, or '69 Camaro would come up behind me in excess of 110 MPH, one 'click' and they were immediately riveted back to a more respectable 75 mph, just like me. And then, just when they thought the coast was clear (and, just as I heard and felt 400 horses let loose), I would let off with another 'calming dose of reality,' and bango, they were now at a paltry 66 MPH. I loved it, great amusement on a cross-country jaunt.

Anyway, someone must have found this little gadget to be as much fun as I did because it disappeared shortly after I bought it. (I think my wife threw it away, something about being easily amused and creating a traffic accident potential????.)

I also am looking for another one of these gadgets, please advise if you find one.

Two weeks ago, I spoke to Doreen at 'The Edge Company' and asked her to give me some vendor information since they no longer sold this electronic toy. She called back a week later and her research was unsuccessful. If you find a supplier, contact me via KJZ@LeachUSA.com.

via Internet

Dear Nuts & Volts:

I read Fred Blechman's article on "Build an Infrared Detector" (May 2000).

I built one years ago, then by chance, found an easier way to check infrared remotes.

Use an AM radio tuned to 530 (dead spot) and push the buttons on the remote. Voila! Tones come out.

Ever try it?

73 Bob

Fred's Reply:

I was unaware of this simple test. Yes, it really does work, if you hold the remote pretty close to the radio antenna. This again proves there is almost always an easier way to do anything! Thanks for the tip.

Fred "Sparks" Blechman K6UGT

I have set up a web site to distribute schematics and source code for my third-prize winning entry in the ExpressPCB contest. Please refer readers to the URL below, and have them click on PIC Web Servers.

http://cheung.place.cc

If the above site is unavailable, try this backup site:

http://redrival.com/dr_ed/

Edward Cheung, Ph.D.

Open Channel

by Joseph J. Carr

Calculating Radio Antenna Bearings: The Great Circle

> If you use a directional antenna in your radio work, then it might be nice to know the direction in which to point the thing. The trick is to know the great circle bearing between your location and the other station's location. That bearing is calculated from some simple spherical trigonometry using a hand-held calculator or a computer program.

Before talking about the math, however, we need to establish a frame of reference that makes the system work.

Latitude and Longitude

The need for navigation on the surface of the earth caused the creation of a grid system to uniquely locate points on the surface of our globe. Figure 1 shows how this system works. Longitude lines run from the North Pole to the South Pole, i.e., from north to south. The reference point (longitude zero) — called the prime meridian — runs through Greenwich, England (Figure 2). The longitude of the prime meridian is 0 degrees. Longitudes west of the prime meridian are given a plus sign (+), while longitudes east of the prime are given a minus (-) sign. If you continue the prime meridian through the poles to the other side of the earth, it has a longitude of 180 degrees. Thus, the longitude values run from -180 degrees to +180 degrees, with ±180 degrees being the same line.

The observatory at Greenwich is also the point against which relative time is measured. Every 15-degree change of longitude is equivalent to a one-hour difference with the Greenwich time. To the west, subtract one hour for each 15 degrees, and to the east, add one hour for each 15 degrees. Thus, the time on the east coast of the United States is -5 hours relative to Greenwich time. At one point, we called time along the prime meridian Greenwich mean time (GMT), also called Zulu time to simplify matters for CW operators. It is also called Universal Coordinated Time.

Latitude lines are measured against the Equator (Figure 2), with distances north of the Equator being taken as positive, and distances south of the equator being negative. The Equator is 0 degrees latitude, while the north pole is +90 degrees latitude, and the south pole is -90 degrees latitude.

Navigators long ago learned that the latitude can be measured by "shooting" the stars and consulting a special atlas to compare the angle of certain stars with tables that translate to latitude numbers. The longitude measurement, however, is a bit different. For centuries, sailors could measure latitude, but had to guess longitude (often with tragic results). In the early 18th century, the British government offered a large cash prize (£20,000) to anyone who could design a method that could be taken to sea. A chronometer won the prize (after many political problems!). By keeping the chronometer set accurately to Greenwich mean time, and comparing GMT against local time (i.e., at a time like high noon when the position of the sun is easy to judge), the longitude could be calculated. If you are interested in this subject, then most decent libraries have books on celestial navigation.

The Great Circle

The shortest distance between two points is a straight line, right? No, not on a globe. On the surface of a globe, a curved line called a great circle path is the shortest distance between two points. This path can cause some interesting anomalies. For example, I live on a latitude that is close to the latitude of Lisbon, Portugal (in which case, why do they get the good weather?). Given that fact, one might assume that I would point my beam due east, i.e., at a bearing of 90 degrees from true north. If I did that, I might hear Portuguese voices coming over the receiver, but they would be from the west coast of Africa, i.e., close to Angola (a former Portuguese colony).

Figure 3 shows the basic problem for calculating antenna bearings. Consider two points on a globe: "A" is your location, while "B" is the other station's location. The distance "D" is the great circle path between "A" and "B."

The great circle path length can be expressed in either degrees or distance (e.g., miles, nautical miles, or kilometers). To calculate the distance, it is necessary to find the difference in longitude (L) between your longitude (LA) and the other guy's longitude (LB): L = LA - LB. Keep the signs straight. For example, if your longitude (LA) is 40 degrees, and the other guy's longitude (LB) is -120 degrees, then L = 40 - (-120) = 40 + 120 = 160. The equation for distance (D) is:

$$\cos D = (\sin A \times \sin B) + (\cos A \times \cos B \times Cos\ L)$$

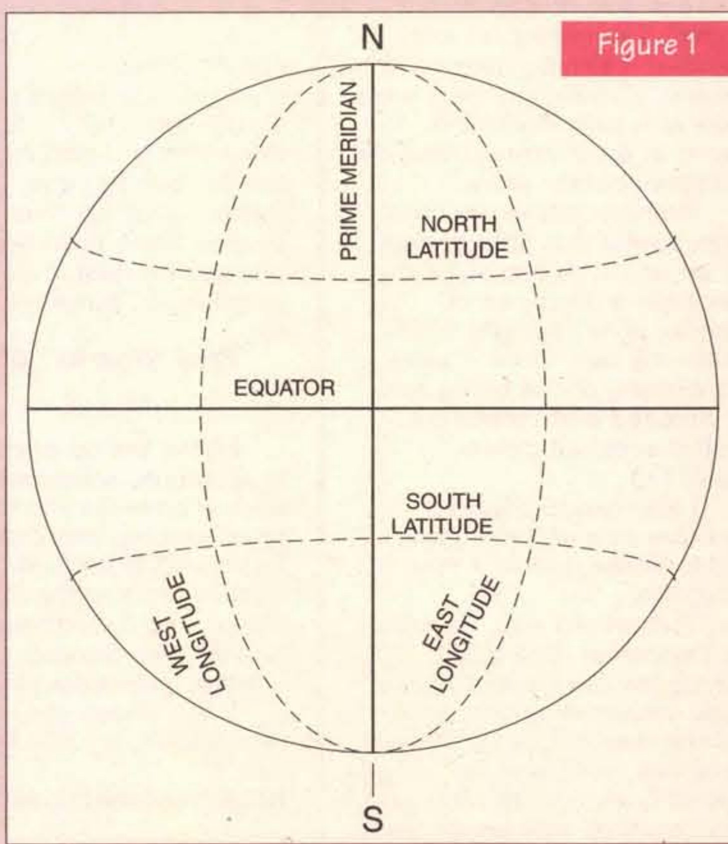


Figure 1

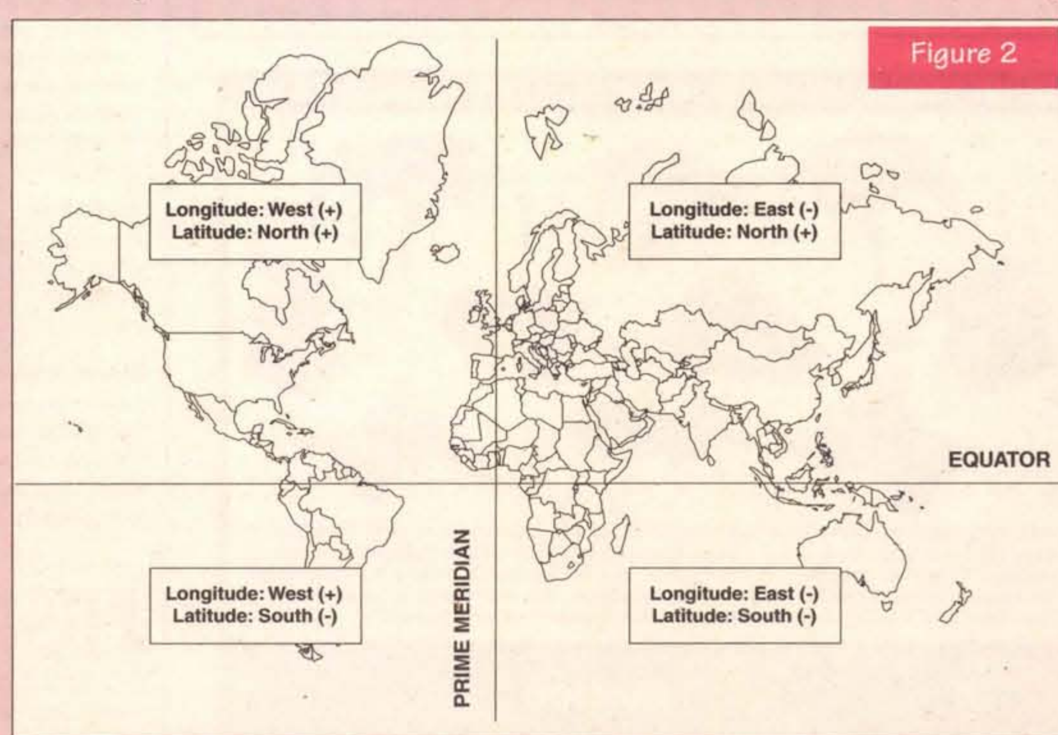
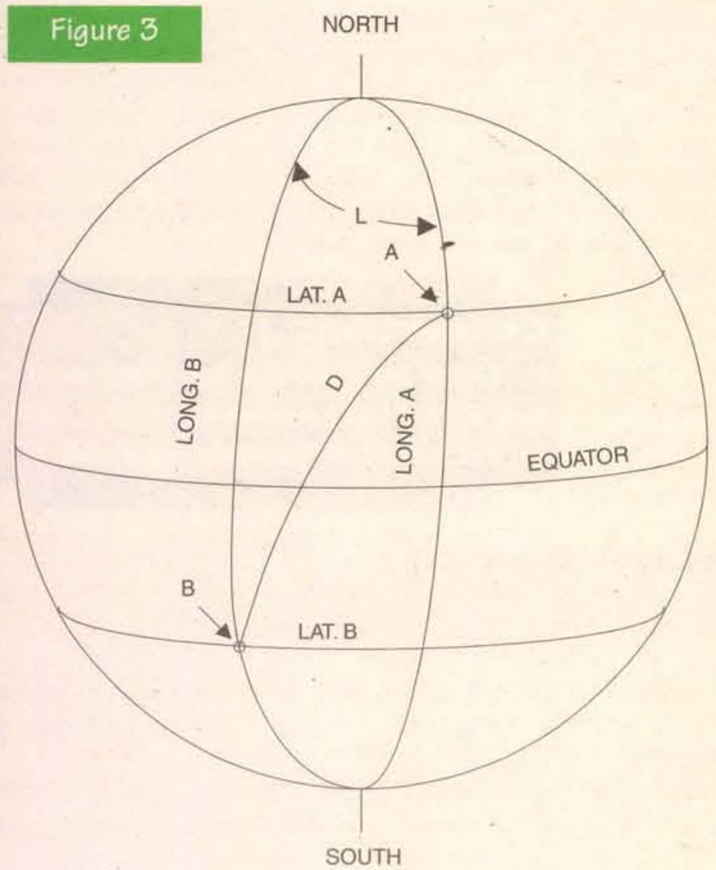


Figure 2

Calculating Radio Antenna Bearings

Figure 3



where:

D is the angular great circle distance
A is your latitude
B is the other station's latitude

To find the actual angle, take the arccos of Eq. (1), i.e.,

$$D \ = \ \arccos(\cos D)$$

In the next equation, you will want to use D in angular measure, but later on will want to convert D to miles. To do that neat trick, multiply D in degrees by 69.4. Or, if you prefer metric measures, then D x 111.2 yields kilometers. This is the approximate distance in statute miles between "A" and "B."

To find the bearing from true north, then work the equation below:

$$C \ = \ \arccos\left[\frac{\sin B \ - \ (\sin A \times \cos D)}{(\cos A \times \sin D)}\right]$$

Now, for the rub: This equation won't always give you the right answer, unless you make some corrections.

The first problem is the "same longitude error," i.e., when both stations are on the same longitude line. In this case, L = LA - LB = 0. If LAT A > LAT B, then C = 180 degrees, but if LAT A < LAT B, then C = 0 degrees. If LAT A = LAT B, then what's the point of all these calculations?

The next problem is found when the condition $-180° \leq L \leq +180°$ is not met, i.e., when the absolute value of L is greater than 180°, ABS(L) > 180°. In this case, either add or subtract 360 in order to make the value between ±180°:

If L > +180, then L = L - 360
If L < -180, then L = L + 360

One problem seen while calculating these values on a computer is the fact that in computer languages such as BASIC, the sin(X) and cos(X) cover different ranges. The sin(X) function returns values from 0° to 360°, while the cos(X) function returns values only over 0° to 180°. If L is positive, then the result of Eq.(3), bearing C, is accurate, but if L is negative, then the actual value of C = 360 - C. I ran across this problem when trying to compare the results of calculations from New York, NY (40.43N, 77W) to Japan and points in Australia. I had expected some bearings in the northwesterly direction because of the great circle map published in older editions of the *ARRL Antenna Book*. Oops! After doing a bit more research, I found the error and added the test below to calculate the case L < 0 then, L = 360 – L, Else L = L.

Another problem is seen whenever either station is in a high latitude near either pole (±90°), or where both locations are very close together, or where the two locations are antipodal (i.e., on opposite points on the earth's surface). According to Hall (1973), the best way to handle these problems is to use a different version of Eq.(3) that multiplies by the cosecant of D (i.e., csc(D)), rather than dividing by sine of D (i.e., sin(D)).

Safety Article

I was heartened to see the response to my article on electronic safety. I got lots of emails and a couple of snail mails on the subject. There were enough stories presented to produce another complete article, but we will confine ourselves to a few additional pointers.

Isolation Transformers

Electrical safety on the workbench often depends on the use of an isolation transformer. The isolation transformer is a 1:1 or possibly 2:1 transformer that operates your 120-volt AC appliances, test equipment, soldering iron, or whatever you're working on. And that's the main purpose of the isolation transformer: it isolates the working side of the AC power lines and ungrounds the neutral. This produces a "floating" AC power main that won't go to ground through you if you accidentally touch the AC power line! The 2:1 transformer is used with 240-volt AC power mains, while the 1:1 is used with the standard 120 volt AC power mains.

Figure 4 shows the wiring of a typical isolation transformer. The transformer will contain a 120-volt outlet and

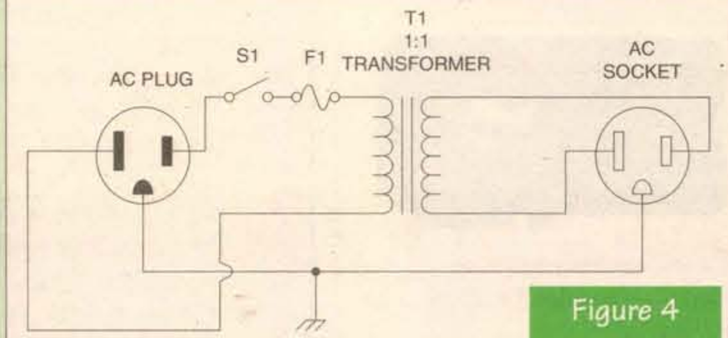


Figure 4

Reference

Jerry Hall, KIPLP (1973). "Bearing and Distance Calculations by Sleight of Hand," QST, August 1973, pp. 24-26.

a plug for the input. It may also contain either a fuse or a circuit breaker to protect the transformer in case of a short circuit. It may also contain a switch to turn the transformer on and off. There may also be a voltmeter across the output to indicate the output voltage of the transformer. This is often an "expanded scale" voltmeter that operates from 95 volts to about 135 volts. Such a voltmeter will enhance your ability to read the output voltage.

Wrenched Backs

I was really surprised to find out from the response to the article on safety that I was not either the first or the only guy to experience a wrenched back while installing an antenna! Be careful, and always use the buddy system!

First QSO

In an ARRL newscast, received by email, we see the following headline: UK-CANADA CROSS-BAND LF QSO COMPLETED. The text follows:

"In the spirit of the early transatlantic tests, a crossband LF-HF contact between the United Kingdom and Canada was completed September 10. The contact involved well-known LFer Dave Bowman G0MRF operating on 135.711 kHz and John Currie VE1ZJ, on Cape Breton Island, Nova Scotia, Canada, operating on 20 meters."

"Dave had a surprisingly strong signal into FN95, Cape Breton Island," Currie said in an email message to Andr' Kesteloot N4ICK who's involved with the AMRAD LF experiment in the US."

"Using spectral software, Currie reports that he observed "weak dashes" from G0MRF just after 2205 UTC on September 9. He says noise was extremely low. Shortly after sunset on Cape Breton Island, he observed a lot of dashes."

"It looked like G0MRF was coming across the pond," he said. Bowman's signal was never audible in Canada. Currie said he had "solid copy on G0MRF" by 2245 UTC, and the crossband QSO was completed on September 10 at 0008 UTC. 'I could see every dot and dash,' he reported. By 0100, he could no longer copy the signal, and by 0250 UTC they were fading. "I did not see them on the spectrogram again," he reported.

Bowman says he was operating from a 15th floor West London apartment, the home of Sean Griffin 2E1AXK. The antenna was two sloping 250-foot long wires about 80 degrees apart. Grounding was via the building's plumbing. Loading involved fixed and variable inductors. Bowman estimated maximum power into the antenna at 700W, but at one point, he dropped his power to about 320W and VE1ZJ was still copying.

"Even allowing for the large antenna, I believe this shows that many UK/EU stations will be able to make the transatlantic path this winter," Bowman said. Canada has not yet authorized Amateur Radio operation at 136 kHz, but some stations have been given permission to experiment there. Larry Kayser VA3LK and Mitch Powell VE3OT completed the first two-way LF contact in Canada on July 22 on 136 kHz, using very slow-speed CW (dubbed "QRSS").

Kayser is testing equipment and processes in preparation for the TransAtlantic II attempt on LF set to occur November 10-27 from Newfoundland. TransAtlantic II will attempt to span the Atlantic in both directions on LF. Details on the project are available at www.rac.ca/vlftest.htm. Bowman's "G0MRF Projects Web-Site" is at www.g0mrf.freeserve.co.uk/.

The Amateur Radio Research and Development Corporation — AMRAD — has been involved in a low-frequency experimentall beacon project in the Northern Virginia-Washington, DC vicinity. AMRAD has been conducting tests on 136.75 kHz from 12 Northern Virginia sites using the experimental call sign WA2XTF. Visit the AMRAD Web page for more information, http://www.amrad.org/. The ARRL has petitioned the FCC for two low-frequency amateur allocations. **NV**

Connections ...

I can be reached by snail mail at P.O. Box 1587, Annandale, VA 22003, or via email at CARRJJ@AOL.COM.

Lew McCoy — Silent Key

And, in another story, the ARRL reports the death of an amateur radio legend, Lew McCoy W1ICP. The text follows:

Amateur Radio legend and former ARRL Headquarters staff member Lew "Mac" McCoy W1ICP of Mesa, AZ, died July 31 following a lengthy illness. He was 84.

As a member of the ARRL Headquarters staff from 1949 until 1978, McCoy gained a national and international reputation primarily for his articles in *QST* and his early work to combat TV interference.

"He became a hero of all the novices and beginners because his stuff was so down to earth and easy to read," said retired ARRL Communications Manager George Hart W1NJM, a good friend.

ARRL Executive Vice President David Sumner K1ZZ described McCoy as "one of a kind" and "versatile." Sumner said McCoy "left his mark on future generations of amateurs as *QST's* 'Beginner and Novice' editor." When FM repeaters came along, Sumner said, McCoy made it his mission to educate his ARRL colleagues about their potential.

An ARRL Life Member, McCoy was first licensed as W9FHZ and later became W0ICP. He arrived at ARRL Headquarters in 1949 to fill the job of assistant communications manager for phone. He went on to work in the Technical Department where he was able to take advantage of his ability to explain technical concepts in simple terms.

McCoy earned a reputation as a tireless traveler and goodwill ambassador for Amateur Radio. He first started hitting the road in the early 1950s after TVI had become troublesome for amateurs and soon became the League's TVI expert. McCoy toured the country demonstrating TVI cures for hams and TV service personnel alike.

ARRL Lab Supervisor Ed Hare W1RFI credited McCoy with providing the foundation for the ARRL's current RFI expertise in helping hams to deal with interference to consumer equipment and interference to hams from other sources. McCoy also was well-known for one of his projects, "The Ultimate Transmatch," an antenna tuner he described in a July 1970 *QST* article.

After leaving the ARRL Headquarters staff, McCoy continued as a *QST* contributing editor. He subsequently was a major contributor to other Amateur Radio publications, including **CQ**.

During his active years on the air, McCoy was an avid DXer with more than 300 countries confirmed. More recently, he was active in the Quarter Century Wireless Association, had served as QCWA president and a board member, and had just been elected again to the QCWA's Board of Directors, something his daughters never got to tell him before he died.

McCoy's first wife, Martha, died in 1998. Survivors include his wife, Clara Gibbs McCoy, and his daughters, Marsha Ashurst W1HAQ and Sharon Armann ex-WN1GQR, as well as grandchildren and great-grandchildren.

In accordance with McCoy's wishes, there will be no funeral. The family is planning a memorial service for McCoy in early December. In lieu of flowers, the family is requesting memorial donations in Lew McCoy's name to Hospice of the Valley, 1510 E. Flower St., Phoenix, AZ 85014-5656. Condolences may be sent to the family care of Marsha Ashurst, P.O. Box 2260, Lakeside, AZ 85929.

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

As promised last time, this month I'm focusing on the theory behind robotic drive systems. There's a lot of math, but none of it is more advanced than simple trigonometry. Heck, you don't even need to know trig if your robots don't tackle hills steeper than about 12 degrees. I'll even walk you through several example calculations involving both large and small robots.

If your eyes glaze over at equations, hang on because I've also got a classic metalworking book to recommend.

By Guess And By Golly

How do I select a motor for my robot? How much weight can the servos carry in my robot drive system? What speed motors should I look for? How fast will my robot be if I use larger wheels? And what do the ratings of this @#$%! motor mean?

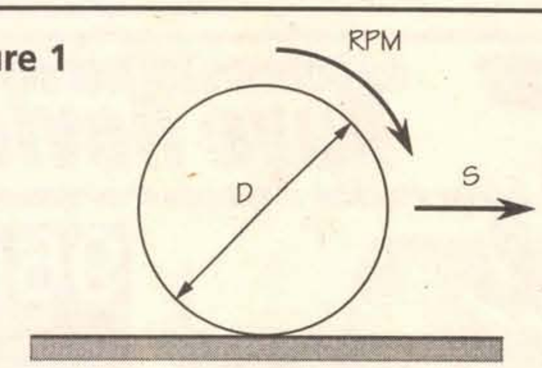
I get asked these sorts of questions all the time, and they are questions I have to ask myself with every new robot I design. Sometimes I choose my motors "by guess and by golly;" I heft the motor, power it up with clip leads to my bench power supply, and observe how fast it turns. For smallish gearmotors, I might then grab hold of the shaft to get a feel for how much torque it has behind it – definitely not something to try with any random motor!

Often I can tell by just this sort of cursory examination whether a given motor is suitable for the job at hand. I have been playing with fractional horsepower motors for over 30 years and building robots for over 25, so I suppose there's quite a bit of subconscious knowledge that comes into play (knowing what motors are big enough to make grabbing the running shaft hazardous would be one of those things). I can often tell at a glance whether a motor is sized right for a robot.

I recall wandering around the exhibit hall of the Second BEAM Robot Olympics in Toronto back in '93. I was revelling in the amazing variety of robots – pancake-flat robots less than a centimeter tall, solar-powered light seekers, micromouse maze runners, sumo wrestler robots, and, so help me, a 'bot powered by beer – when I nearly got flattened by the GCC Wild Thing – a distinctly non-biologically-inspired walking machine built for speed. Its motors were plenty powerful – too powerful to be fully controllable. (I had a similar experience a couple years ago at Trinity with a robot called Max dV built by Marc Warren, though Marc's 'bot was, to his credit, [mostly] in control.)

At BEAM, though, as at most amateur robotics gatherings, the problem most robots faced was not enough power. I remember in particular an otherwise beautifully-constructed hexapod whose motors looked too weak even to support the weight of the robot frame, much less make it walk under load. The builders shyly admitted they didn't have a very good feel for how strong their motors needed to be.

Figure 1



Equations of wheel motion on level surface at fixed speed with no frictional losses

Standard units	SI units
Robot speed in feet per second	Robot speed in meters per second
(1a) $S = \dfrac{D \times RPM}{229}$	(1b) $S = \dfrac{D \times RPM}{1910}$
Wheel speed in revolutions per minute	Wheel speed in revolutions per minute
(2a) $RPM = \dfrac{229 \times S}{D}$	(2b) $RPM = \dfrac{1910 \times S}{D}$
Wheel diameter in inches	Wheel diameter in centimeters
(3a) $D = \dfrac{229 \times S}{RPM}$	(3b) $D = \dfrac{1910 \times S}{RPM}$

Still, though, I sometimes guess wrong about the capabilities of a given motor. When I want to be sure about a motor, I test or I do calculations or both. In Figures 1 through 4, I've distilled some basic equations for calculating torques and speeds as they apply to robots (at least robots with wheels).

Maxing Out Jiffy

So what do all these equations tell me about my Jiffy robot? What would be Jiffy's speed if I changed wheel size? Then, too, I have plans to eventually add a small manipulator arm to Jiffy, so how much extra weight could Jiffy actually carry? (See the July and Aug. 2000 issues of *Nuts & Volts* for construction details on Jiffy.)

As currently built, Jiffy uses four 3.625" wheels (8.7 cm) driven by Futaba S148 servos modified for continuous rotation. Each are rated for about 42 in-oz torque. The robot as a whole has 180 in-oz of torque available to it (with an important caveat, which I'll discuss later).

Servo speeds aren't specified in RPM because they don't rotate continuously; instead, a transit time is given for the servo to turn 60 degrees. The S148 is rated at 0.22 sec/60-deg, which is about 45 RPM.

First of all, let's consider speed. Equation 1 tells me Jiffy's speed

given the wheel diameter and the RPM of the motors:

S = (D x RPM) / 229
= (3.625" x 45 rpm) / 229
= .71 ft/sec

This jibes with my experience of Jiffy's gentle pace. But what if I used wheels larger than the 3.625"-diameter peanut butter jar lids it now uses? What if I use a 4.5" wheel, how fast would Jiffy be then?

S = (4.5" x 45 rpm) / 229
= .88 ft/sec

Okay, so Jiffy is never going to set any speed records. How about the weight it could carry? In order to figure that, I have to make some assumptions about rolling resistance and friction.

From my copy of Mark's *Standard Handbook for Mechanical Engineers,* I gleaned values for rolling resistance Cr of a rubber pneumatic tire over various surfaces (Figure 2). A Cr of .015 corresponds to a hard surface such as concrete, 0.08 for a medium-hard surface such as a boardwalk, and a whopping 0.30 for a soft surface such as freshly-tilled earth. It's almost impossible to know what the actual rolling resistance of a given wheel — such as a peanut butter jar lid — will be without experimentation; it depends on too many factors. I would guess a Cr of 0.3 would be about right, though, for Jiffy running on carpet.

In this case, I use Equation 7, though rearranging to solve for Fw since I know (or can guess) the rest of the values. I'll assume that the max load situation occurs when Tp = Tf:

Fw = Tp / (Cr x r)
= (180 in-oz)/(0.3 x 1.8125")
= 331 oz
= 20.7 lb

Whoa, Can't Be Right!

Twenty pounds seems suspiciously high to me. Perhaps Jiffy could carry a 25-pound load on soft carpet — but not for very long, not up an incline, and not without a shove to accelerate it up to speed.

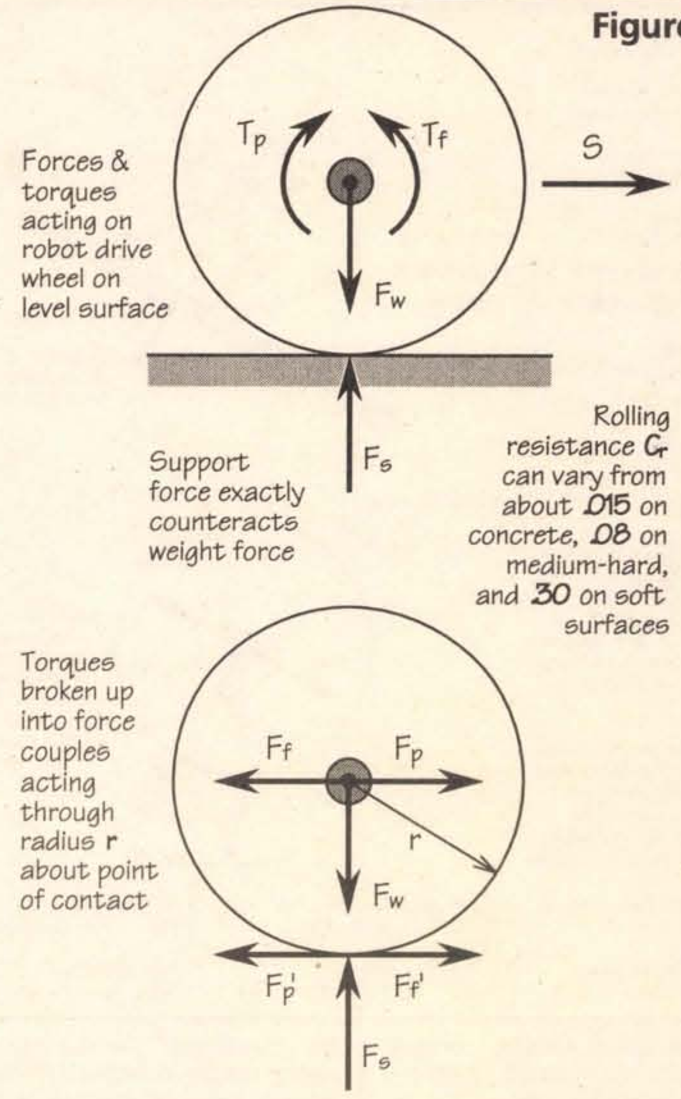
The problem here is that the torque ratings given for servos are usually the stall torque — but nothing actually moves when a gearmotor is stalled, a pretty boring situation for a

For the mathematically curious, the basis for the shallow slope approximation is something called the Taylor Series expansion for the sine and cosine functions. A Taylor series is a regular pattern of numbers in an infinite series that, when added up, yields the function in question. For sine and cosine, it so happens the Taylor series expansions are:

sin x = x - x3/3! + x5/5! - x7/7! + ... etc.
cos x = 1 - x2/2! + x4/4! - x6/6! + ... etc.

For values of x much less than one, the x3 in sine and the x2 in cosine are very small numbers, and the succeeding terms are all vanishingly small. For the purposes of rough design, it's thus perfectly okay to ignore every term but the first in both series when x is small. Thus, sin x can be approximated by x, and cos x by 1.

Figure 2



Force due to weight
(4) $F_w = F_s$

Force due to rolling friction C_r
(6) $F_f = C_r \times F_w$

Propulsion torque
(5) $T_p = F_p \times r$

Frictional torque
(7) $T_f = F_f \times r$
$= C_r \times F_w \times r$

Propulsion force
(5a) $F_p = T_p / r$

Force down the plane
(8) $F_{dp} = F_w \times \sin b$

Force normal to the plane
(9) $F_n = F_w \times \cos b$

Force due to friction
(10) $F_f = C_r \times F_n$

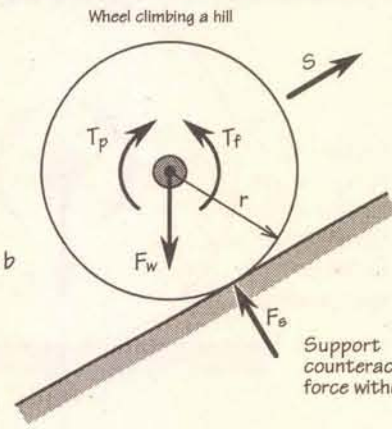
Propulsion force
(11) $F_p = F_{dp} + F_f$
$= F_w \times \sin b + C_r \times F_w \times \cos b$
$= F_w \times (\sin b + C_r \times \cos b)$

Frictional torque
(12) $T_f = F_f \times r = C_r \times F_n \times r$
$= C_r \times F_w \times \cos b \times r$

Propulsion torque
(13) $T_p = F_p \times r$
$= F_w \times (\sin b + C_r \times \cos b) \times r$

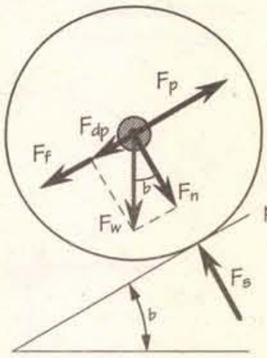
Wheel climbing a hill

Figure 3



Support force can't counteract the weight force without **friction**

For **small values** of angle b, $\sin b \approx b$ and $\cos b \approx 1$, but only when angle b is expressed in **radians**. To convert an angle in degrees to radians, simply multiply the number of degrees by .01745.



Here the weight force is broken up into two **force components**, a component F_n normal (perpendicular) to the plane and a component F_{dp} down the plane

Using the above small-angle assumption, we can replace the above equations with simpler approximations, accurate to within 2% for angles less than 12 degrees:

Force down the plane
(14) $F_{dp} \approx F_w \times b$

Force normal to the plane
(15) $F_n \approx F_w$

Force due to friction
(16) $F_f \approx C_r \times F_w$

Propulsion force
(17) $F_p \approx F_w \times (b + C_r)$

Frictional torque
(18) $T_f \approx C_r \times F_w \times r$

Propulsion torque
(19) $T_p \approx F_w \times (b + C_r) \times r$

robot. The speed ratings, contrariwise, are for the no-load condition, also a pretty boring state.

Of more interest are the maximum-power torque, which is half the stall torque for permanent magnet motors, and the maximum-efficiency torque, which is less still. A conservative guess puts the maximum efficiency torque at about 1/3 the stall torque. It's good practice to design robots to operate near the max efficiency point of their motors; the batteries last longer, the motors themselves last longer because there's less heat build-up, and it leaves the robots with some torque reserve to handle unexpected loads.

My experience also suggests that other things would go wrong with such a high load on a lightly-built robot (Jiffy only weighs a bit over a pound). Servos aren't built to take large overhung loads on their shafts; being made of plastic they tend to bind with more than a pound or two on them. A ball-bearing servo would help, but they cost more. Assuming 1/3 the rated torque of the four servos combined is actually the usable torque, I get about 60 in-oz, and I conclude that Jiffy could handle about seven pounds on a level surface.

A more realistic design assumes there will be hills. How much could Jiffy carry up, say, a 15-degree slope? To answer this, I use Equation 13, solving for Fw as before:

Fw = Tp / ((sin b + Cr x cos b) x r)
= (60 in-oz) / ((sin 15 + .3 x cos 15) x 1.8125")
= (60 in-oz) / ((.2588 + .3 x .9659) x 1.8125")
= (60 in-oz) / (.5486 x 1.8125")
= 59.7 oz
= 3.7 lbs

As always, I'd do a little testing to verify this number, but this seems much more in line with what I know Jiffy can do. And, to answer my original question, since Jiffy itself weighs about a pound, it could probably comfortably carry a robot arm weighing as much as two pounds. (In practice, I'd want the arm to weigh less, because I want the arm to be able to actually pick something up, and Jiffy has to be able to carry that load as well.) Now on to a bigger robot.

Roboschlepper

As I said last time, Roboschlepper was designed as an aid to carry groceries, laundry, and packages for a paraplegic person — to follow a wheelchair as a kind of robotic pack animal. The controls and sensors for such a robot are quite complex, of course, but what I'm interested in here are the mechanical requirements.

In my first design iteration six years ago, Roboschlepper was to weigh about 230 lbs (~104 Kg) fully loaded, with a design speed of five mph — about 7.33 ft/sec (~2.24 m/sec). It was to use 10.5" diameter (.27 m) pneumatic tires from Azusa Engineering and would have to negotiate a variety of surfaces, indoor and outdoor. Some of those surfaces might be slopes as steep as 1 in 12 (i.e., 4.76 degrees, or .083 radians), the steepest wheelchair ramp likely to be encountered. How much torque, then, would Roboschlepper require from its motors to meet these performance requirements?

Since wheelchairs themselves would have trouble negotiating soft earth, Roboschlepper will stick to the harder surfaces, so a rolling resistance Cr of .08 seems appropriate as a first guess.

Since the slope is shallow, I can use Equation 22 to calculate the propulsive force. Note that the shallow-slope approximation yields a slightly higher value for the force, a good thing since it's always better to overestimate the force required.

I'll simplify things still further by assuming Roboschlepper won't be required to accelerate up the ramp, so the (m x a) acceleration term drops out of the equation, leaving:

Fp = Fw x (b + Cr)
= (230 lb) x (.083+.08)
= (230 lb) x .163
= 37.49 lb

Rounding up gives 38 lb as the required traction force. The torque required is given then by Equation 13:

Tp = Fp x r
= (38 lb) x (10.5"/2)
= 199.5 in-lb
= 16.625 ft-lb

Since the robot uses a dual-motor drive, each motor need supply only half this torque, or about 8.31 ft-lb. Using Equation 2a I calculate the wheel RPM:

RPM = (229 x S) / D
= (229 x 7.33 ft/sec) / 10.5"
= 1678.57 / 10.5
= 159.9 RPM

So, I need motors that together produce 16.6 ft-lb of torque at about

160 RPM. I'll talk in detail about power next time, but for now, I can calculate the total horsepower to move the 230-lb robot uphill at 7.33 ft/sec as follows:

HP = (Fp x S) / 550
= (38 lb x 7.33 ft/sec)/550
= .506 HP

Half a horsepower! Even dividing that between the two motors means each must produce 1/4 HP. I could have gone out and bought 1/4 HP motors, but I thought it wise to do a second iteration to see what relaxing the design parameters would do for me.

First, I decided Roboschlepper would have to slim down, slow down, and take easier ramps. I set the new design weight at 200 lbs (~91 Kg), the new speed to three mph (4.4 ft/sec, or 1.34 m/sec) on a slope of 1 in 20 (2.86 degrees, or .05 radians). This is actually the preferred maximum slope for wheelchair ramps, anyway.

Plugging these numbers into the above equations yields Fp = 26 lbs, Tp = 11.4 ft-lb, RPM = 97 RPM, and HP = .21 HP. Split between two motors, I now only needed to find a motor capable of producing 5.7 ft-lb torque at 97 RPM, corresponding to an individual motor HP rating of just over 1/10 HP.

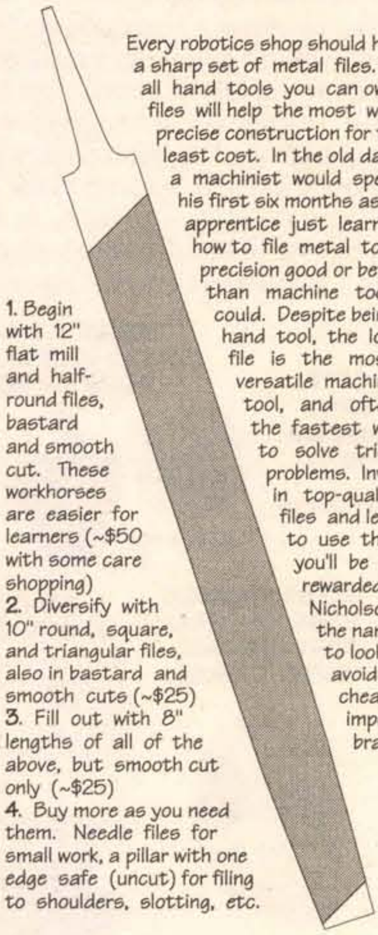
I ultimately chose two 1/8 HP gearmotors out of the Graingers catalog (Dayton # 4Z128A), rated for 43 in-lb torque (3.6 ft-lb) at 167 RPM. Unlike the servos discussed above, the torque rating is at the rated speed, so I don't need to use the 1/3 stall-torque assumption. Additional 2:1 reduction miter gears give a final torque of 7.2 ft-lb delivered to each wheel at 83.5 RPM. This is a little slower than the second iteration design spec, but there's torque left over so these motors could probably meet the spec anyway. By the way, these are definitely motors whose shafts I would not grab hold of while they're running.

The lesson is don't be too rigid on initial design specifications; relaxing one or more constraints can substantially reduce the performance required, making it easier to find — and afford — the right motor.

All of this material is covered (more or less) in any freshman physics course, but if you are truly physics or math-impaired, take a look at *The Cartoon Guide to Physics* by Larry Gonick and Art Huffman (Harper Perennial, New York, 1991, ISBN 0-06-463618-6). I like this book a lot, and for the budding amateur roboticist who hasn't yet got freshman physics under the belt, I heartily recommend it, because it covers mechanics and electricity and magnetism. And it has lots of funny pictures that teach the needed concepts with humor and charm.

Anyway, that's enough formula work for one column. After writing so many equations my head hurts, and my favorite cure for that kind of headache is to go drill holes in metal for a while.

The Universal Machine Tool



Every robotics shop should have a sharp set of metal files. Of all hand tools you can own, files will help the most with precise construction for the least cost. In the old days, a machinist would spend his first six months as an apprentice just learning how to file metal to a precision good or better than machine tools could. Despite being a hand tool, the lowly file is the most versatile machining tool, and often the fastest way to solve tricky problems. Invest in top-quality files and learn to use them; you'll be well rewarded. Nicholson is the name to look for; avoid the cheapy import brands.

1. Begin with 12" flat mill and half-round files, bastard and smooth cut. These workhorses are easier for learners (~$50 with some care shopping)
2. Diversify with 10" round, square, and triangular files, also in bastard and smooth cuts (~$25)
3. Fill out with 8" lengths of all of the above, but smooth cut only (~$25)
4. Buy more as you need them. Needle files for small work, a pillar with one edge safe (uncut) for filing to shoulders, slotting, etc.

TIP: Soft metals, such as aluminum, will clog the teeth of most files; use a wire brush or file card to remove these "pins" so the file will cut evenly without gouging the surface. Chalk on the teeth before filing also helps.

Figure 5

In order to move, a robot's propulsion must overcome all forces opposing its motion:

$$F_{tot} = F_f + F_{dp} + F_a + F_d = F_p \qquad (20)$$

Where:
F_f = Force due to rolling friction
F_{dp} = Force down plane
F_a = Inertial force
F_d = Drag force

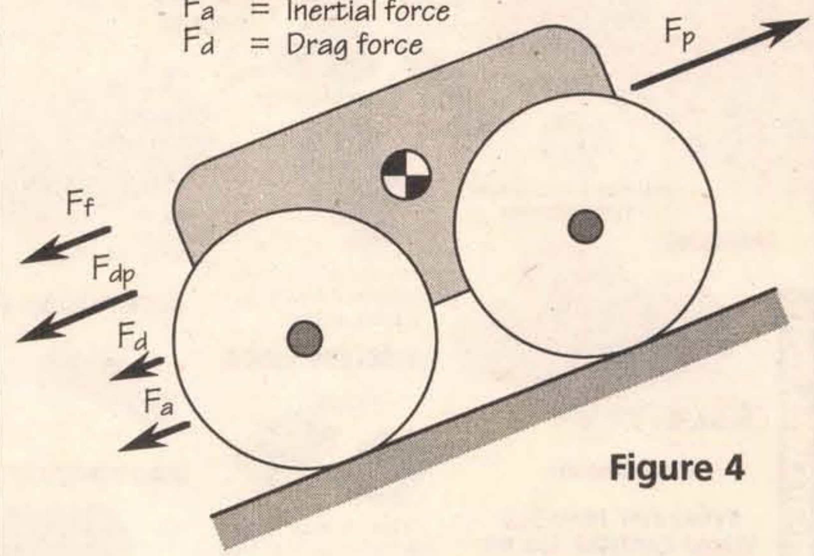


Figure 4

Neglecting drag and wheel rotational inertia:

$$F_p = F_w \times (\sin b + C_r \times \cos b) + (m \times a) \qquad (21)$$

Assuming a shallow slope to climb:

$$F_p = F_w \times (b + C_r) + (m \times a) \qquad (22)$$

The Reluctant Machinist

Every robot builder at some time has to do some machining to make a custom component, especially for larger robots such as Roboschlepper. These days, I find most amateur robot builders enter the field with strong skills in electronics, software,

NOTEBOOK

or mechanics — but rarely in all three. In the last 10 years in particular, I've noticed more and more software people are becoming interested in robotics, and while they often know some electronics, too, many of them don't have much in the way of mechanical skills.

Generations ago, before fuel-injection, front-wheel drive, and clean air regulations, all hackers fooled with car engines, and they accordingly had to know their way around metal shop tools. These days, hackers know their way around compilers, networks, databases, HTML, and hash tables, but they are often lost when it comes to using machine tools. Used to squashing bugs in code, they (and the people around them) are in mortal danger when they fire up a drill press.

In the interest of saving you software sorts — and you know who you are — from as many cuts, contusions, abrasions, and outright amputations as possible, I'm gathering resources to set you on the path to righteous machining.

This month, I want to tell you about my favorite tool book of all time, *The Complete Modern Blacksmith* by Alexander G. Weygers (Ten Speed Press, Berkeley, 1997, ISBN 0-89815-896-6).

I know, I know, some of you out there are saying, "Come on, Nansel, blacksmithing?! What does pounding on redhot horseshoes have to do with robotics?"

First off, that guy pounding on the horseshoe is a farrier, a well-paid specialist these days. A blacksmith is — or was — a general metal worker who, among many gifts, could design, build, and repair tools. In the early years of the 20th century when the nearest lathe or milling machine might be in a shop three counties away, blacksmiths were the guys you depended on to keep your machinery working. If you really want to understand tools and their uses, you should know something about the art and science of blacksmithing, and this book is the best introduction to the subject that I know of.

Actually, the book is a compilation of the author's three books, *The Making of Tools*, *The Modern Blacksmith*, and *The Recycling, Use, and Repair of Tools,* all originally published by Van Nostrand Reinhold in the '70s. In these books the author, through his clearly written text and his engaging, artful hand-drawn illustrations on the margins of every page, leads the reader to the proper way to think about tools and the materials they work. He does so with a passion, love, and, above all, clarity evident in all his drawings. From the introduction to his first book, *The Making of Tools*:

This book teaches the artist and craftsman how to make his own tools: how to design, sharpen, and temper them.

Having made tools (for myself and for others) for most of my life, I have also enjoyed teaching this very rewarding craft, finding that anyone who is naturally handy can readily succeed in toolmaking. The student can begin with a minimum of equipment, at little expense. Using scrap steel (often available at no cost), he can start by making the simplest tools and gradually progress to more difficult ones. Once a student has learned to make his own tools, he will be forever independent of having to buy those not specifically designed for his purpose.

Weygers learned his craft in 1916 at the college of Marine Engineering in Groningen, Holland. He learned to make the tools to make the tools that made steam engines, and his book can teach you skills no less valuable today. Mr. Weygers is no longer with us, alas, but his book is. I realize that most of you — even the gung-ho mechanical types — aren't likely to build a substantial fraction of the tools you use, even after reading this book. Still, there is much wisdom and skill to be gleaned from *The Complete Modern Blacksmith*. This book is a steal at $19.95. Get it, and get inspired.

Next Time

I had been planning to present some upgrades to Jiffy for this time, but I discovered too late that Jiffy had gotten crunched by the baggage gorillas on its last plane trip — two wheels fractured and the power switch lever snapped clean off. Therefore, next time I get back to drilling holes with some repairs and upgrades to Jiffy. I've had a great response to the Jiffy project, and thanks to this, I even have photos of another Jiffy built by a reader.

Finally, I've got the Trinity Fire Fighting Home Robot competition on my mind since I've been watching the 2000 competition video. I'm itching to get started on a fire fighter robot. Now, where did I leave my hammer and tongs ... **NV**

If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

Robert Nansel
Box 228
Ambridge, PA 15003

Email: bnansel@nauticom.net

Events CALENDAR

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

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Events Calendar
430 Princeland Court
Corona, CA 92879
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

NOVEMBER 2000

November 4

FL - SORRENTO - Hamfest. Lake ARA, John Gable W8KCE, 352-394-2723. Email: w8kce@aol.com
NH - LONDONDERRY - Hamfest. Londonderry Lions Club, Mammoth Rd. Talk-in: 146.850. The Interstate Repeater Society ARC, Paul 603-883-3308. Email: Harold@neainc.com
NJ - LAWRENCEVILLE - Hamfest. Lawrence High School, 2525 Princeton Pike. 8am-1pm. VE exams. Talk-in: 146.670, PL 131.8. Delaware Valley RA, 609-882-2240. Email: w2zq@arrl.net Web: www.slac.com/w2zq
NM - SOCORRO - Hamfest. Socorro ARA, Tech ARA, & City of Socorro, Al Braun AC5BX, 505-835-3370. Email: ac5bx@juno.com Web: http://www.ees.nmt.edu/sara/
OK - ALTUS - Hamfest. Altus Area ARA, MK Schenkel W5VXU, 580-846-5578. Email: w5vxu@juno.com
OK - ENID - Hamfest. Garfield County Fairgrounds, Hoover Bldg. 8am-5pm. Talk-in: 147.15+, 444.40+. Enid ARC, Tom Worth N5LWT, 580-233-8473; email: n5lwt@hotmail.com or Fred Selfridge WA5OU, 580-242-3551
WA - FERNDALE - Hamfest. Ferndale Band Boosters Bingo Hall. 9am-2pm. Talk-in: 146.74/14. Mount Baker ARC, Al Norton K7IEY, 360-354-4622. Email: k7iey@netscape.net

November 4-5

GA - LAWRENCEVILLE - Hamfest. Gwinnett County Fairgrounds. Sat: 9am-5pm, Sun: 9am-3pm. Talk-in: 145.45-(PL107.2), 444.25+ (PL131.8), 146.76-(PL107.2). Alford Memorial RC, 770-410-3989. Email: KR4NQ@bigfoot.com Web: www.totr.radio.org
TX - ODESSA - Hamfest. Ector County Coliseum, Bldg. D, 42nd & Andrews Hwy. 8am-5pm. VE Testing. Talk-in: 145.470/444.425/HF 3.922. West TX ARC, Craig Martindale W5BU, 915-366-4521. Email: w5bu@hotmail.com

November 5

IA - DAVENPORT - Hamfest. IA National Guard Hangar, Mt. Joy Airport. Davenport RAC, Dave Mayfield W9WRL, 309-762-6010 or 309-757-1880. Email: hamfest@gwltd.com Web: http://www.gwltd.com/hamfest
IL - PEORIA - CIRC's Second Annual Robotics Competition. Lakeview Museum of Arts and Sciences. Email: circ@mtco.com Web: www.circ.mtco.com
MA - FRAMINGHAM - Hamfest. Framingham ARA, Beverly Lees N1LOO, 508-626-2012
MI - ST. JOSEPH - Hamfest. Playland Hall. 8am-12pm. VE Testing. Talk-in: 146.82-146.72 (if 82 is down). Blossomland ARA, Duane Durflinger KX8D, 616-982-0404. Email: comdac@comdac.com
PA - LINGLESTOWN - Hamfest. Firehall, 5901 Linglestown Rd. VE session. Talk-in: 145.47. Central PA Repeater Assn., Harold Baer KE3TM, 717-566-8895
WI - APPLETON (KAUKAUNA) - Hamfest. Starlite Club, Corner Hwy. 55 & CR JJ. VE sessions. Talk-in: 146.52. Fox Cities ARC, John Ensley N9RJZ, 920-830-3194. Email: n9rjz@arrl.net Web: http://www.w9zl.ampr.net

November 11

AL - MONTGOMERY - Hamfest. S. AL State Fairgrounds, Garrett Coliseum, Federal Dr. 9am-3pm. FCC Exams. Talk-in: 146.24/84. Montgomery ARC, Phil C. Salley K4OZN, 334-272-7980. Email: k4ozn@arrl.net Web: http://jschool.troyst.edu/~w4ap/
CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
CO - GOLDEN - Hamfest. Jefferson County Fairgrounds, 15200 W. 6th Ave. 8am-2pm. VE Testing. Talk-in: 144.62/145.22 MHz. Rocky Mountain Radio League, Inc., Ron Rose N0MQJ, 303-985-8692. Email: n0mqj@arrl.net
FL - PORT ST. LUCIE - Hamfest. St. Andrew Lutheran Church, 295 N. Prima Vista Blvd. 8am-2pm. Talk-in: 146.955-. Port St. Lucie ARA, Roy Cox KT4PA, 561-340-4319. Email: roycox@ecqual.net Web: http://www.qsl.net/pslara
HI - HONOLULU/OAHU - Hamfest. Koolau ARC, Walt Niemczura AH6OZ, 808-263-3872 or 808-956-7503. Email: walt@hawaii.rr.com Web: http://www.chem.hawaii.edu/karc/
TX - AZLE - Hamfest. 7am-3pm. Talk-in: 147.16 CTCSS 110.9, 147.42 simplex. Tri-County ARC of North TX, Jerry Buxton N0JY, 817-523-4426. Email: n0jy@arrl.net Web: http://www.qsl.net/tcarc-ntx/ncttech.html

November 17-18

MS - OCEAN SPRINGS - Hamfest. West Jackson County ARC, Phil Hunsberger W9NZ, 228-872-1499. Email: w9nzl@juno.com

November 18

FL - CORAL GABLES - Hamfest. University of Miami, Physics Parking Lot. Talk-in: 146.865. U of M ARC, Bill Moore WA4TEJ, 305-264-4465 (day). Email: WA4TEJ@beethoven.com
LA - WEST MONROE - Hamfest. The Barak Shrine Temple. Talk-in: 146.85. Twin City Ham Club, Jim Ragsdale W5LA, 318-396-9529. Email: W5LA@hamtutor.com Web: http://www.tchams.org/users/hamfest
MA - NEWTONVILLE - Auction. Newton Masonic Hall, 460 Newtonville Ave. 11am-4pm. Talk-in: 146.64-. Waltham ARA & 1200 RC, Eliot Mayer W1MJ, 617-484-1089. Email: w1mj@amsat.org Web: http://www.wara64.org/wara/auction.htm
OH - GEORGETOWN - Hamfest. Grant ARC, Dot Silman KB8TQU, 937-446-2234. Email: huggee@bright.net Web: http://www.qsl.net/~n1djs

November 18-19

IN - FORT WAYNE - State Convention. Allen County War Memorial Coliseum and Exposition Center, 4000 Parnell Ave. Sat: 9am-4pm, Sun: 9am-3pm. ACARTS, James Boyer KB9IH, 219-489-6700. Email: jboyer@ail.com Web: http://www.acarts.com

November 19

NC - BENSON - Hamfest. Johnston ARS, Paul Dunn KD4BJD, 919-894-3100

November 25

FL - OCALA - Hamfest. Booster Stadium, N.E. 36th Ave. 8am-2pm. Talk-in: 146.97 or 146.61. Marion County Repeater Owners Assn. & Silver Springs RC, Mario N4TSV, 352-472-2240. Email: n4tsv@amsat.org
IN - EVANSVILLE - Hamfest. Vanderburgh County 4-H Center Fairgrounds Auditorium. 8am-2pm. Talk-in: 145.150-Evansville 146.925- and 443.925+ Vincennes. EARS, Neil Rapp WB9VPG, 812-479-5741. Email: earsham@aol.com Web: http://members.aol.com/earsham/hamfest.htm

November 26

IL - WHEATON - Radio Fest. DuPage County Fairgrounds. GMRS of Illinois, 630-393-3937or 815-436-7090. Email: alf3148@megsinet.net

DECEMBER 2000

December 2

GA - CLAXTON - Hamfest. Claxton AR Emergency Service (CARES), Ellie Waters W4CJB, 912-653-4939. Email: ellie@premierweb.net

December 2-3

FL - PALMETTO - Hamfest. Manatee County Convention and Civic Center, 1 Haben Blvd. Talk-in: 146.730. FGCARC, Jean Endicott KC4KZU, 727-525-5178. Email: kr4yl@arrl.net Web: http://www.fgcarc.org

December 3

IN - GREENFIELD - Hamfest. Greenfield High School Pavilion, Broadway St. 8am-2pm. HARC, Tom Donaldson N9LFU, Email: tomd@freewwweb.com General info: 317-326-3168. Web: www.w9atg.org
MI - MT. CLEMENS - Hamfest. L'Anse Creuse High School. 8am-2pm. FCC exams. Talk-in: 147.080+, simplex 146.520. L'Anse Creuse ARC, Donna Luh KA8QBD, 248-651-7387. Email: jrluh@aol.com Web: http://www.ameritech.net/users/lc-arc/index.html

December 9

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
SC - UNION - Hamfest. Union National Guard Armory. 8am-2pm. Union County ARC, Roger Gregory W4RWG, 864-427-1462. Email: rgregory@carol.net

JANUARY 2001

January 6

TN - MORRISTOWN - Hamfest. Lakeway ARC, John Ellenburg KE4QIH, 423-581-5645. Email: ellenburg@icx.net
WI - WAUKESHA - Hamfest. Waukesha Co. West Allis RAC, Phil Gural W9NAW, 414-425-3649

January 12-13

FL - FT. MYERS - Hamfest. Ft. Myers ARC, Earl Spencer K4FQU, 941-332-1503. Email: k4fqu@juno.com

January 13

TX - SAN ANTONIO - Hamfest. Little Joe's Country Gold, 7405 Old Pearsall Rd. San Antonio RC, Royce Taylor KA5OHJ, 210-

COMPUTER SHOWS

AGI Shows, 317-299-8827. E-Mail: info@agishows.com http://www.agishows.com

Blue Star Productions 612-788-1901. http://www.supercomputersale.com

Computers And You, 734-283-1754. www.a1-supercomputersales.com

Computer Central Shows 847-412-1900 & 1-888-296-6066. E-Mail: compcent@megsinet.net www.computercentralshows.com

Computer Country Expo 847-662-0811 Web: www.ccxpo.com

Five Star Productions 810-379-3333. E-Mail: jeff@fivestar www.fivestarshows.com

Georgia Mountain Productions 706-838-4827. E-Mail: gamtnpro@blrg.tds.net georgiamountain.com

Gibraltar Trade Center, Inc. 734-287-2000. Taylor, MI. E-Mail: taylor@gibraltartrade.com www.gibraltartrade.com

Gibraltar Trade Center, Inc. 810-465-6440. Mt. Clemens, MI. E-Mail: mtclemens@gibraltartrade.com www.gibraltartrade.com

KGP Productions 1-800-631-0062, 732-297-2526. E-Mail: kgp@mail.com

MarketPro, Inc., 201-825-2229. http://www.marketpro.com

MarketPro, Inc., 301-984-0880. E-Mail: md@marketpro.com http://marketpro.com

Narisaam Computer Show 770-663-0983. E-Mail: narisaam@aol.com Web: http://www.shownsale.com

Northern Computer Shows 978-744-8440. E-Mail: inquiries@ncshows.com Web: ncshows.com

Peter Trapp Computer Shows 603-272-5008. Web: www.petertrapp.com

680-0432. Email: swapfest01@juno.com Web: http://community.webtv.net/k5 ucq/SanAntonioRadioClub

January 14

IN - GOSHEN - Hamfest. Michiana Valley Hamfest Assn., Denny Denniston KA9WNR, 219-291-0252 (7-10 PM EST).
OH - NELSONVILLE - Hamfest. Sunday Creek AR Federation, Russ Ellis N8MWK, 740-767-2226. Email: scarf@hocking.edu

January 20

LA - HAMMOND - Hamfest. Southeast LA ARC, Bill Borstel KB5SKW, 225-695-6414. Email: wborstel@aol.com Web: http://www.selarc.org
MO - ST. JOSEPH - Hamfest. Ramada Inn, I-29 & Frederick Ave. FCC exams. Talk-in: 146.85 & 444.925. MO Valley & Ray-Clay ARCs, Carlene Makawski KA0IKS, 816-279-3406. Email: nem3238@ccp.com Web: http://www.kc.net/~oconnor

January 20-21

FL - SARASOTA - Hamfest. Sarasota ARA, Eddie Martin KI4ZJ, 941-378-8371. Email: ki4zj@hotmail.com

January 21

MI - HAZEL PARK - Hamfest. Hazel Park High School, 23400 Hughes St. 8am-2pm. Talk-in: 146.64-. Hazel Park ARC, Inc., Tom Krausnick WC9F, email: wc9f@arrl.org Web: http://www.qsl.net/w8hp
NY - NORTH BABYLON - NLI Section Convention. Babylon Town Hall Annex, Phelps Ln. VE testing. Great South Bay ARC, Phil Lewis N2MUN, 631-226-0698. Email: n2mun@optonline.net Web: www.arrlhudson.org/nli/hru2001.htm
NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. Email: wb2slq@juno.com Web: http://www.metro70cmnetwork cmnetwork.com
VA - RICHMOND - VA Section Convention. The Showplace, 3000 Mechanicsville Turnpike (Rt. 360). 8:30am-3:30pm. Richmond Amateur Telecommunications Society, Pat Wilson K4OW, 804-932-9424. Email: k4ow@arrl.net Web: http://frostfest.rats.net

January 27

FL - ARCADIA - Hamfest. DeSoto ARC, Doug Christ KN4YT, Email: kn4yt@cyberstreet.com

January 28

MD - ODENTON - Hamfest. Maryland Mobileers ARC, Tom Ostrosky W3NI, 410-766-9414. Email: ostrosky@erols.com Web: http://www.space4less.com/mmarc
OH - DOVER - Hamfest. Tusco ARC, Gary Green KB8WFN, 740-922-4454. Email: kb8wfn@tusco.net

FEBRUARY 2001

February 3

SC - NORTH CHARLESTON - Hamfest. Charleston ARS, Jenny Myers WA4NGV, 843-747-2324. Email: brycemyers@aol.com Web: http://www.qsl.net/wa4usn/index.html

February 3-4

FL - MIAMI - Southeastern Division Convention. Fair Expo Center, 10901 SW 24th St. (Coral Way). Dade Radio Club, Evelyn Gauzens W4WYR, 305-642-4139. Email: w4wyr@arrl.net Web: http://www.gauzens.net

February 4

TX - GEORGETOWN - Hamfest. Williamson County ARC, Mike Evans KD5AAD, Email: mlevans@mail.utexas.edu

February 9-10-11

FL - ORLANDO - Northern FL Section Convention. Central Florida Fairgrounds, 4603 W. Colonial Dr. Exams. Talk-in: 146.760 down 600, 145.110 down 600. Orlando ARC, Ken Christenson AF4ZI, 407-291-2465. Email: kd4jqr@juno.com Web: http://www.oarc.org/hamcat.html

February 10-11

TN - MEMPHIS - Convention. Shelby Co. Bldg., Mid-south Fairgrounds. Sat: 9am-5pm, Sun: 9am-2pm. Dixie Fest Committee, Ben Troughton KU4AW, 901-372-8031. Email: ku4aw@arrl.net Web: http://www.dixiefest.org

February 18

MI - FARMINGTON HILLS - Hamfest. William Costick Activity Center, 28600 W. 11 Mile Rd. 8am-1:30pm. LARC, 734-261-5486. Email: swap@larc.mi.org Web: http://larc.mi.org
NY - CHEEKTOWAGA - Hamfest. Leonard Post VFW, 2450 Walden Ave. Talk-in: 147.255. Lancaster ARC, Luke Calianno N2GDU, 716-634-4667 or 716-683-8880. Email: luke@towncountryflorist.com Web: http://hamgate1.sunyerie.edu/~larc

February 25

NY - HICKSVILLE - Hamfest. Long Island Moble ARC, Eddie Muro KC2AYC, 516-520-9311. Email: hamfest@limarc.org Web: http://www.limarc.org
OH - CINCINNATI - Hamfest. Hartwell Recreation Center, May St. off Caldwell Dr. 9am-4pm. ARPSC, 513-661-1805. Email: gldivision@juno.com Web: www.arpsc.com

MARCH 2001

Events CALENDAR

March 2-3

FL - NEW PORT RICHEY - Hamfest. Fred K. Marchman Technical Education Center, 7825 Campus Dr. 8am-5pm. Talk-in: 146.670. Gulf Coast ARC, Rick Brown KF4GXS, 727-863-1457. Email: richar@gte.net. Web: http://gcarc.cjb.net

March 4

NY - LINDENHURST - Hamfest. GSBARC & SCRC, Phil Lewis N2MUN, 631-226-0698. Email: info@gsbarc.org Web: http://www.gsbarc.org

March 10

WA - PUYALLUP - Hamfest. Mike & Key ARC, Michael Dinkelman N7WA, 425-867-4797. Email: mwdink@eskimo.com

March 10-11

NC - CHARLOTTE - Hamfest & ComputerFair. Charlotte Merchandise Mart, 2500 E. Independence Blvd. The Mecklenburg ARS, Tom Hunt KA3VVJ, 704-948-7373 day & eves. until 9pm EST. Email: dealers@w4bfb.org Web: www.w4bfb.org/hamfest.html

March 17

FL - FT. WALTON BEACH - Hamfest. Playground ARC, Louis Carter KF4HRM, 850-243-4315. Email: parcfest@aol.com Web: http://www.bsc.net/playground/

FL - STUART - Hamfest. Martin County ARA, Romund Madson KS4KM, 561-337-1841

March 17-18

TX - MIDLAND - State Convention. Midland ARC, Pete Stull WB7AMP, 915-686-6755 or 915-362-6644. Email: W5QGG@arrl.net

March 18

OH - MAUMEE - Hamfest. Lucas County Recreation Center, 2901 Key St. 8am-2pm. Talk-in: 147.27+. TMRA Hamfest, POB 273, Toledo, OH 43697-0273. Web: www.tmrahamradio.org

March 25

NC - KINSTON - Hamfest. Down East Hamfest Assn., Doug Burt W4OFO, 252-524-5724. Email: jeanhd@icomnet.com

March 31

TX - BRENHAM - Hamfest. Brenham ARC, Dan Lakenmacher N5UNU, 979-836-8739. Email: lindan@pointcom.net Web: http://www.alpha1.net/~barc

March 31-April 1

MD - TIMONIUM - Greater Baltimore Hamboree & Computerfest/MD State ARRL Convention. Timonium Fairgrounds, York Rd. Baltimore ARC, Sharon Dobson N3QQC, 410-HAM-FEST or 800-HAM-FEST. Email: k3duh@amsat.org Web: http://www.gbhc.org

April 8

NC - RALEIGH - Hamfest. Raleigh ARS, Chuck Littlewood K4HF, 919-872-6555. Email: k4hf@arrl.net Web: http://www.rars.org

WI - STOUGHTON - Hamfest. Madison Area Repeater Assn., Paul Toussaint N9VWH, 608-245-8890. Email: n9vwh@arrl.net Web: http://www.qsl.net/mara/

MAY 2001

May 5-6

AL - BIRMINGHAM - Hamfest. Glenn Glass KE4YZK, 205-681-5019. Email: ke4yzk@bellsouth.net Web: http://www.w4cue.com

TX - ABILENE - West TX State Convention. Key City ARC, Peggy Richard KA4UPA, 915-672-8889. Email: ka4upa@arrl.net Web: http://www.angelfire.com/tx/kcarc76/hamfest.html

May 6

NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053. Email: wb2slq@juno.com Web: http://www.metro70cmnetwork.com

May 12

WA - STANWOOD - Hamfest. Stanwood-Camano ARC, Dave Huppert KA7FDC, 360-387-6123. Email: huppert@whidbey.net

JUNE 2001

June 1-2-3

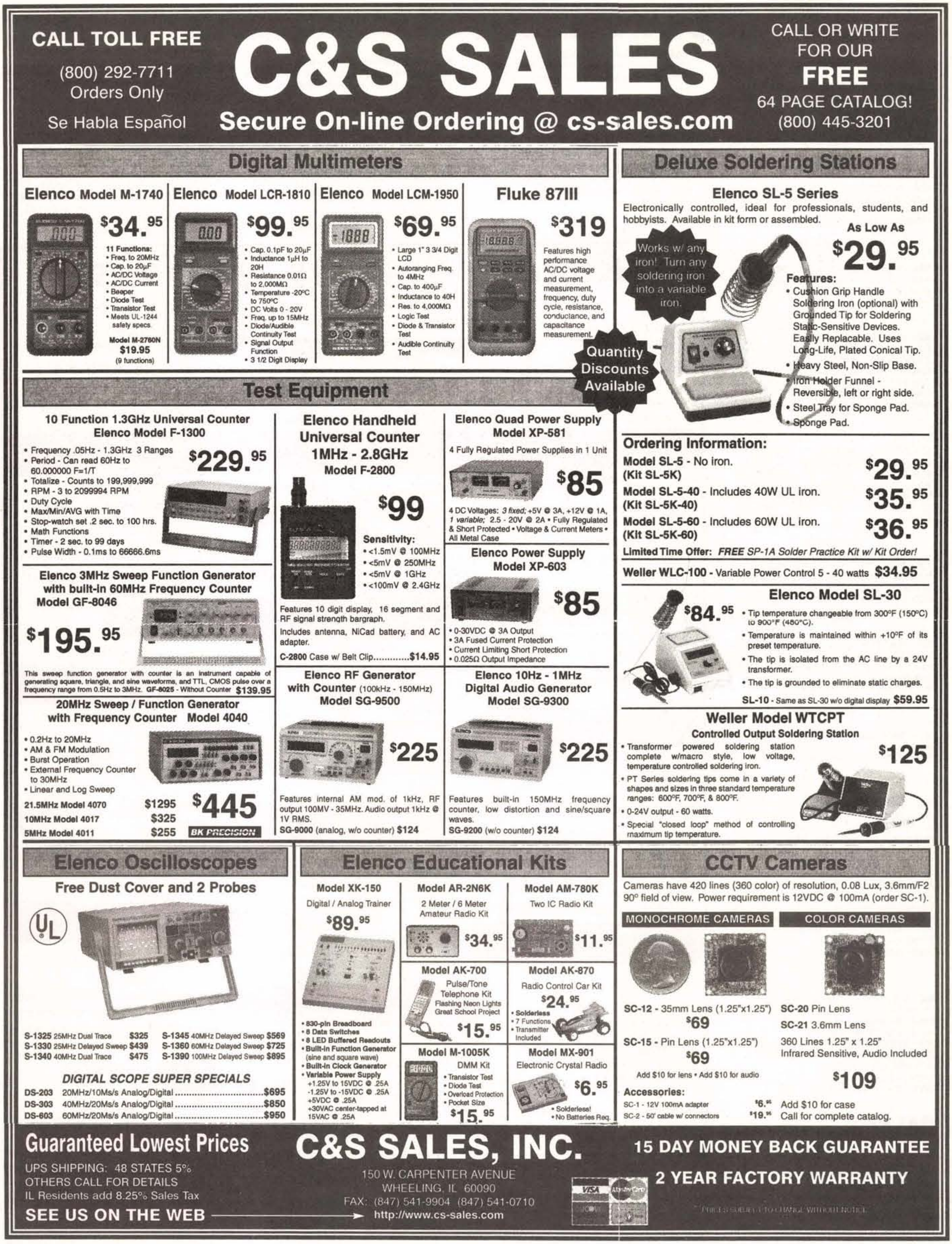
NY - ROCHESTER - Atlantic Division Convention. Monroe County Fairgrounds, Rt. 15A. Fri: 6am-5:30pm, Sat: 8:30am-5:30pm, Sun: 8:30am-1:30pm. Rochester ARA, Harold Smith K2HC, 716-424-7184. Email: harold@rochesterhamfest.org Web: http://www.rochesterhamfest.org

OR - SEASIDE - Northwestern Division ARRL Convention. Convention Center. SEA-PAC, Randy Stimson KZ7T, 503-297-1175. Web: www.seapac.org

June 9

PA - BLOOMSBURG - Eastern PA Section Convention. Columbia-Montour ARC, George Law N3KYZ, 570-784-2299. Email: n3kyz@jlink.net Web: http://www.bafn.org/~cmarc

WI - EAU CLAIRE - Hamfest. Eau Claire ARC, Jim Staatz KG9RA, 715-838-9108. Email: w9eau@ecarc.org Web: http://www.ecarc.org



Write in 174 on Reader Service Card.

ELECTRONICS Q&A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, as well as comments and suggestions. You can reach me at:

TJBYERS@aol.com

or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.

What's Up:

Whistlers primer, active filters, and how they relate to long lengths of wire. A unique relay-operated well pump and garage watchdog. Reader's feedback with old radio and RIAA trivia, and a more serious side of etching PC boards. Finally, some nifty freebies.

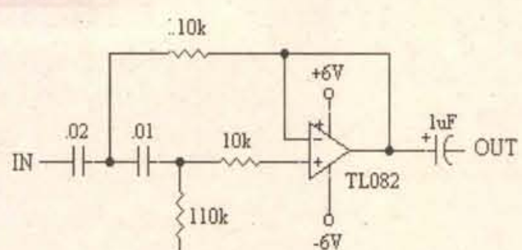
Music Of The Spheres

Q. I'm trying to build a VLF receiver to listen to whistlers and other natural radio sounds, but I'm having a problem. Instead of hearing music of the universe, all I get is a loud hum from the local power lines. I built a simple LC filter using an audio transformer, but still the hum overwhelms the atmospheric sprites. What can I do?

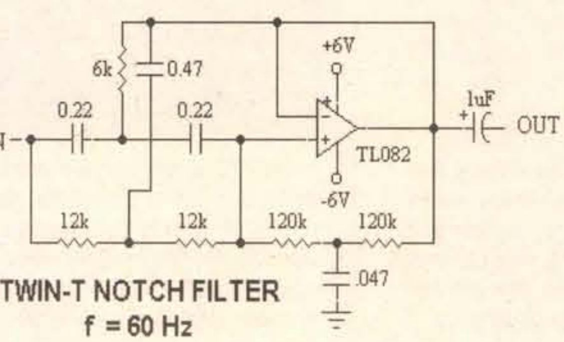
Tim Hardin
via Internet

A. Relatively few people know of the beautiful radio "music" produced naturally by several processes of nature, including lightning storms and aurora, aided by events occurring on the sun. The majority of natural radio (a term coined in the late '80s by Michael Mideke) emissions occur in the very-low and extremely-low frequency (VLF/ELF) range — typically 100 Hz to 10 kHz.

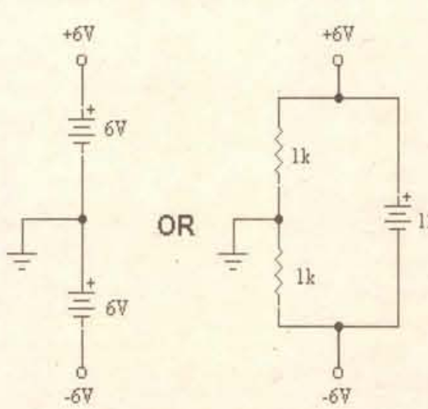
The greatest nemesis to monitoring natural radio is electric AC power lines, which "bleed" strong 60-Hz radio waves into the air. The usual cure is to place the receiver well away from AC power lines, typically 1/2 mile or better. Unfortunately, this isn't always possible, in which case a filter may be your only solution. Here are two.



HIGH-PASS FILTER
f = 100 Hz



TWIN-T NOTCH FILTER
f = 60 Hz



POWER SUPPLY

The top circuit is an active high-pass filter with a cut-off frequency of 100 Hz. That means it attenuates all frequencies below 100 Hz by about 40 dB and passes without loss those above 100 Hz, thereby eliminating the 60-Hz interference. The second circuit is a notch filter, which — unlike the high-pass filter — selectively removes just the 60-Hz hum and lets the frequencies above and below pass unscathed. BTW, if you're using an e-field receiver — the kind with a short whip antenna — it needs to be located away from trees, buildings, and other obstacles by about 100 feet because these objects absorb VLF frequencies; the separation will also reduce AC line interference, making the filters even more effective.

For more information on VLF and natural radio, cruise over to these websites:

BBB-4 VLF Receiver
http://www.triax.com/vlfradio/bbb4b.htm

The VLF Listener's Handbook
http://www.triax.com/vlfradio/vlfhndbk.htm#3

Editor's Note - In our July 1995 issue, Joe Carr's Open Channel column titled "Radio Science Observing" discussed monitoring natures radio signals in depth. Even building your own whistler receiver. Some back issues are still available.

Are You Reeling In The Feet?

Q. I have a large reel of #12 stainless steel wire and would like to use it to build a long wire antenna. I am concerned about the higher resistance over that of copper wire. Would this wire be okay to use?

Francis Hillibush
via Internet

A. Well, let's do some math and see how the two compare. Copper has a resistivity coefficient of 0.0158 microohms per meter and stainless steel has a resistivity coefficient of 0.765 microohms per meter, giving us a ratio of 48.4. What this means is that #12 AWG copper wire has a resistance of 1.59 ohms per foot and #12 AWG stainless steel has a resistance of 76.98 ohms per foot — about the same as #28 AWG copper wire. I've used 28 gauge copper wire for antennas before and had good results (albeit the tensile strength left a lot to be desired), so I imagine your stainless steel will work for some applications. For example, it'll work as a VLF antenna to detect whistlers and Loran broadcasts where the greater length and tensile strength are more important than a few ohms of signal loss. As the frequency increases, though, so does the skin effect (where the current flows on the outside of the conductor and not through the center) so there is a cutoff point where the stainless steel becomes ineffective as a long aerial, but below 1 MHz you should be okay.

Let Me Count The Ways

Q. I'm searching for a backlit LCD electronic counter (totalizer) with at least three digits and electronic reset. The key requirement is a character size of one inch. I have tried my normal sources: Jameco, Digi-Key, Mouser, Newark, McMaster-Carr, Grainger, All Electronics, and local supply houses with no luck. Any ideas?

John Shipley
via Internet

A. Sure, get your checkbook out and spend $800.00 for a professional laboratory instrument. But that's not what you wanted to hear. The problem is your one-inch display requirement. It's very difficult to find a backlit LCD display with characters larger than 0.5 inches (12.5 mm). If you can live with a 0.5-inch display, RadioShack makes a five-digit electronic counting

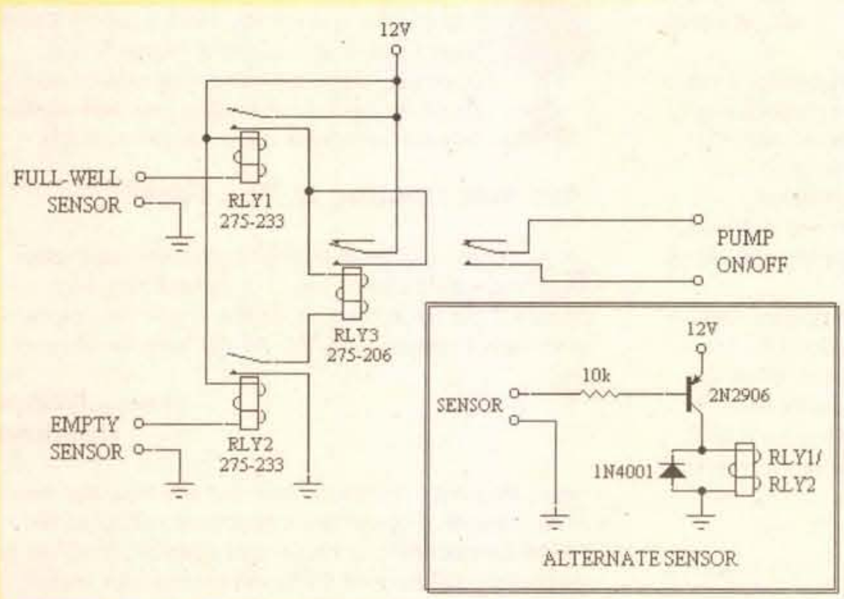
module (910-4910) with all the features you requested. Moreover, it sells for a low $16.99 and operates for nearly a year from a single "AA" battery. Let's see if one of our readers has better luck finding this device than you or I have had. Folks?

Whatcha Gonna Do When The Well Runs Dry?

Q My sprinkler timer engages a well pump via a relay. But when the well goes dry, the pump keeps running. I need a circuit to shut the pump off when the well is empty and prevent the pump from starting again until the well is filled. The season dictates how long it takes for the well to fill, so another timer isn't the answer.

Ken Schultis
Salmon Arm, B.C. Canada

A Because your timer operates a relay, I decided to build the circuit using just relays. They can withstand harsh environments, are immune to power surges, and are generally more trouble-free than their semiconductor counterparts for this application.



RLY1 is the top sensor and RLY2 is the bottom sensor. RLY3 is the controller relay. In order for RLY3 to lull in, both RLY1 and RLY2 must be engaged. This is done when the water level is high enough to contact the Well-Full and Empty sensors. when these sensors come in contact with water, current flows through the relay coil and closes its contacts. Once RLY3 is engaged, it remains that way even if RLY1 turns off because of the unique latching circuit seen on the left contacts. In fact, it remains engaged until RLY2 releases, which happens when the water level drops below the Empty sensor and current ceases to flow through the coil. This breaks the current flow to RLY3 and disengages the latch circuit. However, it isn't until RLY1 is again activated that RLY3 can pull in, preventing the pump from starting until the well is full.

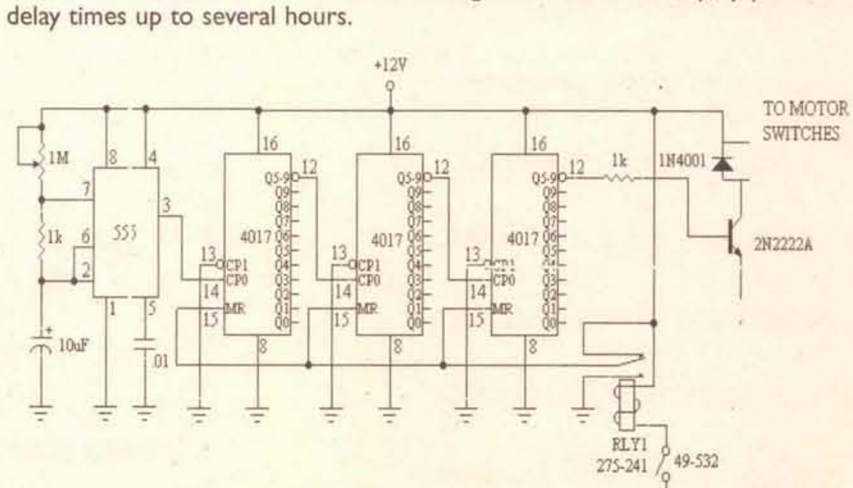
The two sensor relays — RLY1 and RLY2 — are RadioShack 275-233 reed relays that will pull in with just 8 mA of current, which all but the purist of water can conduct easily. If you have problems triggering the sensor relays, the insert shows a modification using a switching transistor that requires just 1 mA of sensor current. The sensor contacts can be made using two pan-head screws screwed into a length of 1/2-inch PVC plastic pipe, which you can buy at any hardware store. The sensors are then positioned in the well at your desired trigger levels.

Time Is On My Side

Q Although I live in a quiet neighborhood, I'm concerned that my garage might be a target for burglary because the automatic door gets left open now and then. As far as I can ascertain, there are never circumstances that require it to be open more than a few hours at a time, so I need a simple circuit, possibly actuated by a switch in the door track, that will time out after two to five hours and close the garage door should I neglect to. My thoughts were that the track switch would start the timer and close the door. After the door is closed, the timer would reset and be ready for another opening cycle.

P. J. Hicks
via Internet

A I don't know your garage controller because you didn't list a model number, but that's okay because there are many different versions of the same out there, so I'm serving up a generic version of what you want. At the heart of this system is the delay timer, which starts counting when the garage door opens and closes the door when the time expires. The key component is the 4017 decade counter/divider, which divides the clock pulses generated by the 555 astable multivibrator by 10, then feeds that pulse to the next 4017 where it gets divided by 10 again, for a total of 100. Add another 4017 divider, and the total is now 1/1000 that of the original clock rate. This ploy permits delay times up to several hours.



Cool Web Sites

You're going to be hearing a lot about RadioShack's newest lure, so let's set the record straight. RadioShack is giving away a bar code reader, called CueCat, that lets you scan their new catalog and order parts over the Internet. Well, actually the scanner is on loan from Digital Convergence and it has a pretty tight lease license. However, this dandy device is also a handy tool that can be used to inventory and/or label your pantry, library, or other personal belongings if you know the behind-the-scenes secret. **www.radioshack.com/Partners/CAT/HomePage/RSCATGateway.asp**

Xicor announces the end of do-it-yourself potentiometers. With Xicor DCPs, there are no moving parts. Just set it and forget it. Xicor's extensive line of digital potentiometers includes devices that can be used in a multitude of applications requiring digital control. For a limited time, Xicor is offereing free samples and a designer's kit. To register for this offer visit http://www.questlink.com/avnet0920

A marketing consultancy, The Fourth Room, has discovered that the Internet is spawning an informal global language, free of capital letters and apostrophes but full of abbreviations and badly spelled words. The coined word for this new language is Weblish.

The easiest way to start the timer is by using a magnetic switch, like the security switches sold by RadioShack (49-532), mounted so that it activates the timer when the door is opened, and resets the timer when the garage door is closed. This is easily accomplished via RLY1. The garage door motor is controlled by RLY2, the wiring of which you'll have to work out for yourself (check your owner's manual) because each motor controller is different. Hope this gives you the security you're looking for.

MAILBAG

Dear Mr. Byers:

I think you overlooked something in your response to the Philco 5AZ4 replacement in the Sept. 2000 issue. You drew the typical dual-diode rectifier and added the thermistor. So far, so good. You show the dynamic speaker coil between the capacitors and note that this was sometimes connected from the center tap to ground. You imply that either connection can be used.

If the coil was originally from the center tap to ground this was probably done because the insulation on some of these coils couldn't withstand the full DC voltage. Placing it in the center tap circuit accomplishes the same thing but eliminates the DC voltage to ground issue. This was also a safety issue if the coil shorted to the speaker frame, not exactly an uncommon occurrence. Remember that a lot of these old radios used wood cabinets so the speaker frames weren't grounded.

Also, sometimes 120-Hz hum in the speaker can be reduced by reversing the coil leads. Some sets actually used the AC current waveform in the coil to reduce the filtering needs of the DC supply to the audio output tube plate. Some high-quality sets also had a hum bucking coil that was fed from the filament supply to handle 60 Hz.

I'm glad some of this old trivia is occasionally useful. This was back when we really understood circuits.

Don Pomeroy
via Internet

Dear TJ Byers:

The RIAA curve playback roll-off at higher frequencies also reduces hiss and surface noise on the recording. This is also the original reason for the pre-emphasis used in FM and TV broadcast audio transmitters with, of course, the de-emphasis incorporated in the receivers.

The (orthocoustic) RIAA/NAB Recording and Playback Standard was adopted in June, 1953, and reaffirmed in March, 1964. The orthocoustic recording characteristic was introduced by RCA and used by the broadcasting and recording industries for many years prior to the introduction of the RIAA/NAB standards.

The late Howard M. Tremaine, in his fabulous book *AUDIO CYCLOPEDIA* states concerning the orthocoustic standard, which is quite similar to the current RIAA/NAB standard, "The principal advantage gained by the use of such equalizers is the increased signal-to-noise ratio above 2000 Hz."

Jim Alexander KOHIP
via Internet

Dear Mr. Byers:

Copper is a no-no in the municipal waste water stream. It kills microbes in the biological treatment process used by most municipalities, and in sufficient quantities, will take out the whole treatment plant for an extended period until the microbes can be regrown. Here in Massachusetts, the maximum limit is <3.0 mG/L. I agree that the amounts used by the home etcher should not cause a problem, but it would be wise to check with the local Waste Water System Manager first. If you have a septic tank, you may have problems with the bacterial action there, too.

Bill Smith
via Internet

Thank you for listing Manual Merchant in your Oct. 2000 column. However, Manual Merchant has since launched a web site, **www.manualmerchant.com,** and a new email address at **info@manualmerchant.com**. In addition, my name has changed from Linda Perkins to Linda Kaplan! The address is P.O. Box 927792, San Diego, CA 92192-7792. The telephone number is **858-642-0785** and the fax number is **858-642-0885**.

Linda Kaplan
Manual Merchant

Switched-Capacitor Filters

by Anton Kruger

Introduction

The circuit in Figure 1 consists of two capacitors and two switches controlled by two non-overlapping clocks, Φ1 and Φ2. When Φ1 is high, S1 closes while S2 is open. When Φ1 goes low, S1 closes. Then after a short delay, Φ2 goes high, and S2 closes. This cycle repeats and S1 and S2 close and open alternatively, but they are never closed at the same time. The input to the circuit is the sum of a 5V, 75 Hz sine and a 1V, 2 kHz sine. The output from the circuit is shown in Figure 2.

For comparison, the output from passing the signal through a first order RC filter with a 500 Hz 3-dB bandwidth is shown, as well. Except for the small stair-casing, the output from the circuit is very close to the output from the RC filter. What is going on here?

The circuit in Figure 1 is what is known as a switched-capacitor filter. When Φ1 is high, S1 is closed and capacitor C_{sc} charges to v_1. Then it opens and C_{sc}c retains the charge and voltage. After a short delay, S2 closes and the capacitor charges to v_2. Now

$$q = CV$$

so that the change in charge is

$$\Delta q = C_{sc}(v_1 - v_2)$$

Recall that current is defined as the charge per unit time transferred, and assume that the period T of the cycle: S1 closes, S1 opens, S2 closes, S2 opens ... is short enough so that the voltages v_1 and v_2 don't change appreciably. It is clear then that the charge transferred by the switched-capacitor can be viewed as a current given by:

$$i = \frac{\Delta q}{T} = \frac{C_{sc}(v_1 - v_2)}{T}$$

From Ohm's Law we can write:

$$R_{sc} = \frac{v_1 - v_2}{i} = \frac{T}{C_{sc}} = \frac{1}{f_{clk} C_{sc}}$$

where $1/T = f_{clk}$ is the clock frequency. Thus, the switched-capacitor acts like a resistor with value given above, in that it will result in the same charge transfer per unit time as a conventional resistor of the same value. With this in mind, we can redraw Figure 1 to reveal its function as an RC lowpass filter, as shown in Figure 3. Plugging in the values shows that the switched-capacitor resistor has a value

$$R_{sc} = \frac{1}{f_s C_{sc}} = \frac{1}{10 \times 10^3 \times 20 \times 10^{-12}} = 5\ \mathrm{M\Omega}$$

The 3-dB or corner frequency of the filter is:

$$f = \frac{1}{2\pi\ R_{sc} C_f} = \frac{1}{2\pi \times 5 \times 10^6 \times 64 \times 10^{-12}} = 497 \approx 500\ \mathrm{Hz}$$

Of course, the current flowing through the switched capacitor resistor is not continuous as with a conventional resistor, which explains the stair-casing in the output. Except for this artifact, however, we have succeeded in building an RC filter without any (conventional) resistor. In practice, the switches S1 and S2 are transistors.

While this may be an intriguing concept, it is valid to question why one would go to all the trouble and expense of overlapping clocks and voltage-controlled switches to replace a simple RC filter. One reason may be that the switched-capacitor resistor is a function of the clock frequency, so that one can change the resistance by varying the clock frequency. In other words, it is an electrically controllable resistor. However, there are easier and cheaper ways of accomplishing this.

To understand why switched-capacitors are useful, one has to understand a few facts about IC manufacturing. The first thing is transistors, and transistors use switches that are cheap and easy to manufacture. Small-value capacitors are also easily manufactured. Small-value resistors are manufactured using strips of the IC chip. This is good for up to a few hundred ohm, but larger values become problematic because they require so much chip real-estate. Chip designers and manufacturers would much rather use several transistors to avoid using one large-value resistor, since it is more cost-effective. This explains why, in a typical IC, the number of transistors outnumber the other components. This is opposite to traditional discrete electronics where transistors are expensive, and resistors and capacitors are cheap.

Transistor-centric designs can be and are very effective in a great many instances. However, there are times where large-value resistors are needed. One example is filters with large time constants. To achieve a large time constant, one needs either a large resistance, a large capacitance, or both. As we have discussed, large capacitances — and especially large resistances — are undesirable in IC designs. Enter the switched capacitor — the circuit in Figure 1 implements a 5MΩ resistor using two switches and a capacitor, but costs next to nothing in an IC.

While the main advantage of switched-capacitors is that they provide a means of implementing large-value resistors, another advantage is that they are electrically-controllable. An additional advantage becomes clear if one considers the expression for the 3-dB bandwidth of the lowpass filter in Figure 1:

$$f_{3dB} = \frac{1}{2\pi\ R_{sc} C_f} = \frac{1}{2\pi\left(\frac{1}{f_{clk} C_{sc}}\right) C_f} = \frac{f_s C_{sc}}{2\pi C_f}. \qquad (1)$$

The corner frequency is a function of the ratio of two capacitances. This is perfect for an IC implementation where it is difficult to make values of individual components exact, but it is easy to control their ratio to within less than 1%.

Commercial Switched-Capacitor Filters

Commercial switched-capacitor filters are high-order active filters, rather than the simple first-order RC filter in Figure 1. However, the principles are the same — virtual resistances are created using a combination of switches and capacitors. Table 1 summarizes some of the ICs available. Packaging options include DIP and SO. Prices range from less than a dollar for the MF4, to $30.00 for the MAX260. Typically, cutoff frequencies can be adjusted over the range 0.1 Hz-40 kHz simply by changing the clock frequency.

Some of the filters in Table 1 are designated as "universal" while others are implicitly "dedicated." Universal filters provide the designer with the basic building blocks and he/she can configure it to form lowpass, notch, bandpass, etc., filters of various types: Butterworth, Bessel, and so on. Dedicated filters are preconfigured filters such as an eighth order lowpass Butterworth, or eighth order lowpass elliptic filter, and so on.

Clock-To-Corner Frequency Ratio

The clock frequency f_{clk} of the simple switched-capacitor filter in Figure 1 is 10 kHz, while the corner frequency is 500 Hz, so that there is a 20:1 ratio between clock and corner frequency. The ratio for commercial switched-capacitor filters is normally 50:1 or 100:1. In some filters, this ratio is fixed and the part number indicates the ratio. Thus, the MF4-50 part from National has a 50:1 ratio, while the MF4-100 part is an identical filter except that it has a 100:1 ratio. Other IC filters allow the user to select one of the two ratios. A high clock/corner frequency ratio reduces the stair-casing, but requires a higher clock frequency that may be undesirable from other circuit constraints.

Characteristics And Applications

The characteristics of a particu-

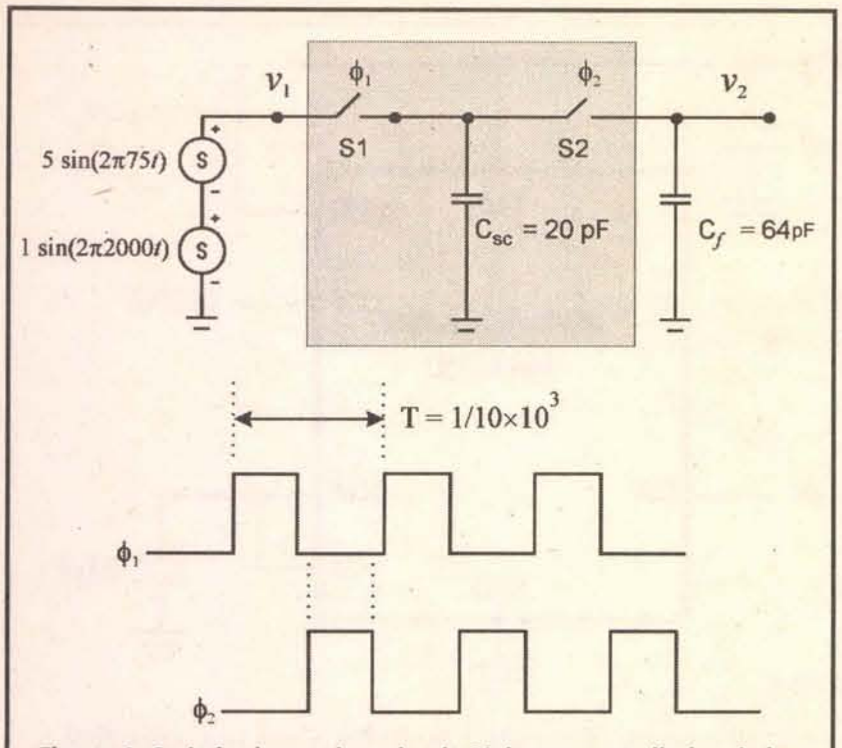


Figure 1. Switched-capacitor circuit. Voltage-controlled switches S1 and S2 are controlled by non-overlapping clocks Φ_1 and Φ_2 running at 10 kHz. When Φ_1 is high, S1 is closed and S2 is open. When Φ_2 is high, S2 is closed, and the switches are never closed at the same time.

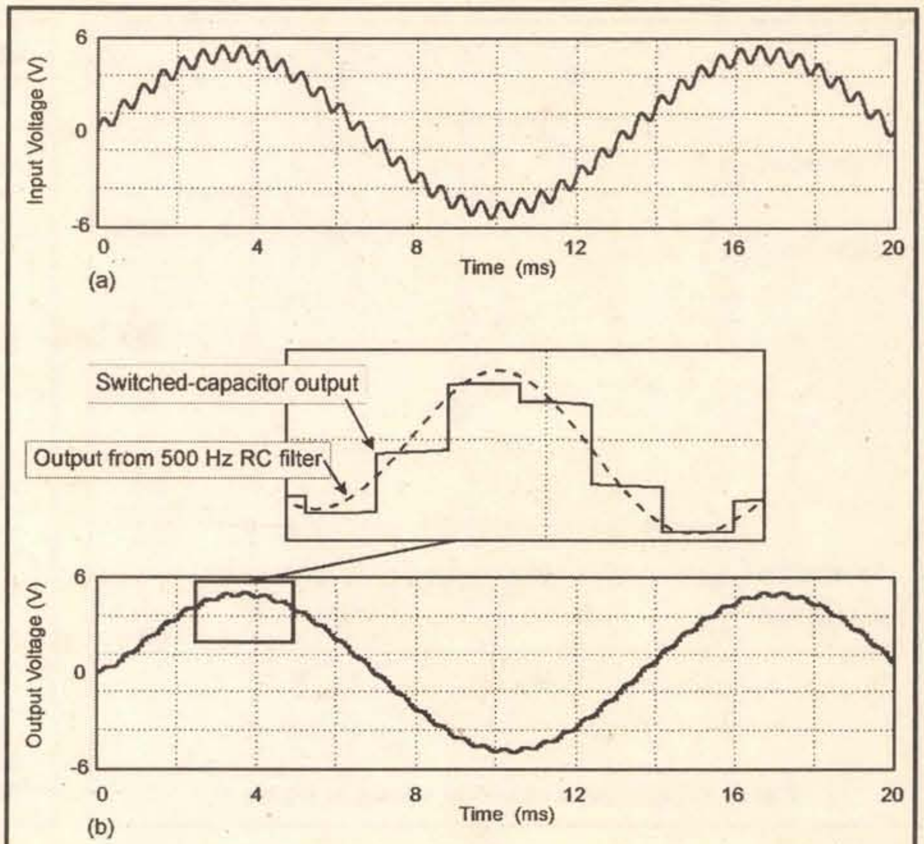


Figure 2. (a) Input to switched-capacitor circuit. (b) Output from circuit in Figure 1. For comparison, the output from a 500 Hz RC filter is shown, as well.

lar switched-capacitor filter obviously depend on the component, but all these filters share some general characteristics. First, the stair-casing in the output is inherent in the technique. It may come as a surprise, but this is, in many cases, not a problem. For example, switched-capacitor filters are often used in filtering the output from a DAC, possibly followed by a conventional analog filter. The stair-casing from the DAC will be much larger than that from the switched-capacitor filter. The idea is that the switched-capacitor filter provides the heavy-duty filtering, so that a relatively simple final analog filter will suffice.

In some instances, the bandwidth of the circuit that follows the switched-capacitor filter may be such that it removes the stair-casing, or the stair-casing may not be important. For example, if the output goes to a speaker with bandwidth of a few kHz, then stair-casing at 50 kHz may be irrelevant in many instances.

In any event, one can always easily reduce the stair-casing by following the switched-capacitor filter with a simple lowpass filter. The corner frequency of this filter is normally the switched-capacitor clock frequency, which is relatively high, and easy to filter out. Here is an instance where a high clock/corner frequency ratio may be an advantage.

Switched-capacitor filters exhibit excellent temperature stability, and a 10 ppm/°C temperature coefficient for the clock/corner frequency ratio is not unusual. This is a direct result of the fact that corner frequencies depend on the ratios of capacitances (see Equation 1), and variations in temperature tend to cancel out. This, and the fact that (for practical purposes) the corner frequency depends only on the clock frequency, is a tremendous advantage over conventional analog filters. Some conventional analog filter designs are quite sensitive to component variations, and it may be difficult and expensive to achieve the same performance.

Designing Switched-Capacitor Filters

Since the switched-capacitor filter is a sampled-data component, one has to be careful to avoid frequency aliasing or folding. Practically, this means one has to ensure that there are no significant frequency components in the input above the Nyquist frequency, which is $f_{clck}/2$. Another thing to watch out for is when the switched-capacitor filter is used to post-filter the output from an DAC. Here it is best to synchronize the filter clock to the DAC clock, otherwise beats between the two clocks may show up in the output. In some cases, a simple RC lowpass filter may be required.

Except for these few simple precautions, it is quite easy to use switched-capacitor filters. A design typically involves matching the specification of the filter with one of the dedicated switched-capacitor filters available, and supplying the appropriate clock signal.

As an example, the MAX7480 switched-capacitor filter requires a single +5V supply, two non-critical decoupling capacitors, and an external clock to implement an eighth order lowpass Butterworth filter with corner frequency adjustable

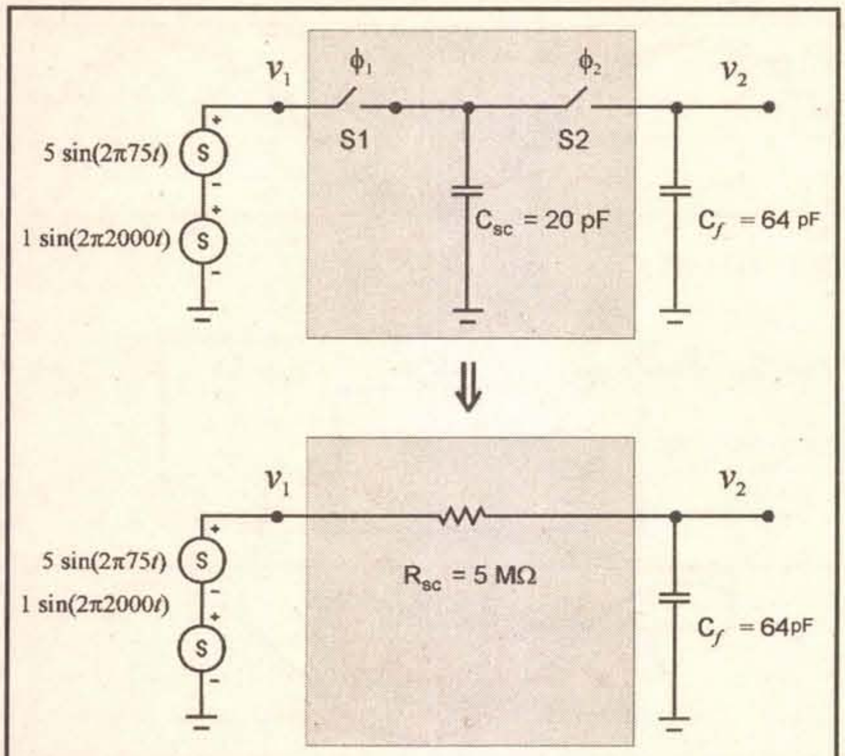


Figure 3. Equivalent of circuit shown in Figure 1.

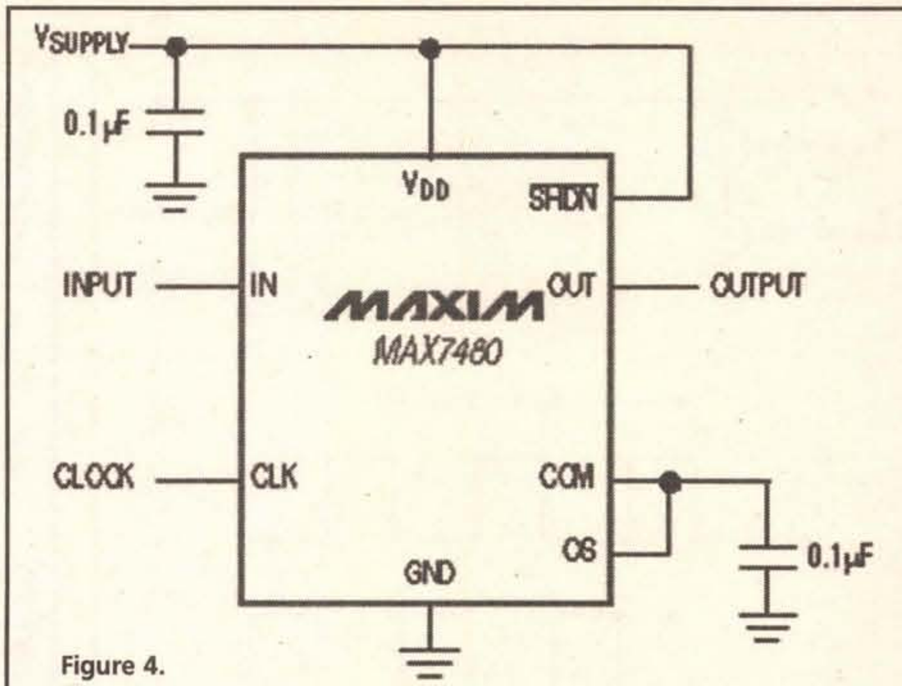


Figure 4.

A switched-capacitor filter using a MAX7480 IC and two non-critical decoupling capacitors. The external clock determines the corner frequency of this eighth order lowpass Butterworth filter according to $f_{clk}/100$.

PART	MANUFACTURER	COMMENTS
MF10	National	Two independent, universal filters. Each can be used to implement first and second order filters. The filters can be cascaded to form third and fourth order sections. Any of the classical filters (Butterworth, Bessel, Cauer, and Chebyshev) can be implemented.
LMF100	National	Pin-compatible with MF10, but offers better performance.
MF4	National	Fourth order lowpass Butterworth filter. Has on-board clock that is set with an external resistor and capacitor or accepts an external clock.
TLC04	Texas Instruments	Texas Instruments' implementation of the MF4.
MAX7480	Maxim	Eighth order, lowpass, Butterworth filter.
MAX263/264 MAX267/268	Maxim	Independent center frequency and Q selectable via input pins. Filter design software available.
MAX291/292	Maxim	Eighth order lowpass filters with on-board or external clock. Frequency range 0.1 Hz-25 kHz.
MAX295/296	Maxim	Same as above, but frequency range is 0.1 Hz-50 kHz
MAX260/261/262	Maxim	Dual, universal, microprocessor-controllable filter with more features than most people will ever need. Filter design software available.

TABLE 1

from 1 Hz to 2 kHz. The corner frequency is $f_{clk}/100$, so to implement a 500 Hz filter, the clock frequency needs to be 100 x 500 = 5 kHz. A sample circuit is shown in Figure 4.

It is also possible to run the filter without an external clock by connecting an external capacitor COSC between the CLK pin and ground. It is hard to imagine a simpler filter implementation than this. The price seems right too – the MAX7480 costs less than $2.50.

If one of the dedicated switched-capacitor filters does not meet one's needs, then a custom design using a universal switched-capacitor filter is called for. One can generally implement any of the popular filter types using standard analog filter techniques. The manufacturers have application notes, and in some instances, software available to ease the design process.

Conclusion

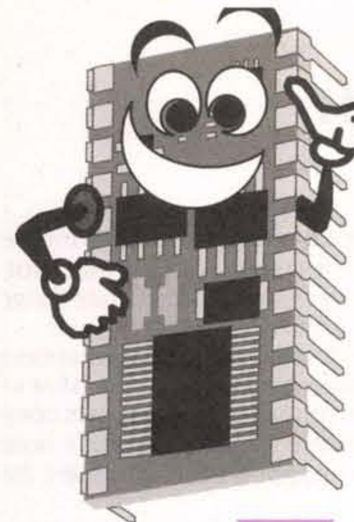
While most people familiar with the different kinds of filters: active/passive, Butterworth, Chebyshev, and so on, a surprising number of people are unaware of switched-capacitor filters, even though they have been around for years. This is really a shame, since these are ingenious designs, easy to work with, and very cost-effective. **NV**

References

"Introducing the MF-10: A Versatile Monolithic Active Filter Building Block." **National Semiconductor http://www.national.com/an/AN/AN-307.pdf AN-307.**

"A Basic Introduction to Filters – Active, Passive, and Switched-Capacitor." **National Semiconductor. http://www.national.com/an/AN/AN-779.pdf AN-779.**

"Programmable Universal Filter Implements C-Message Weighting Function." **Maxim Semiconductor Design Showcase http://www.maxim-ic.com/**



by Jon Williams

Stamp Applications

SOUND IDEAS THE BASIC STAMP II

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

In the past we've talked about adding chips to help the Stamp make sounds. What Bob's neat little project proved to me was that with a little bit of code and imagination, the Stamp's FREQOUT command is capable of some pretty neat things. The best part is that FREQOUT doesn't require any external (sound generating) components.

At a recent DPRG gathering, my friend and fellow Stamp enthusiast, Robert Jordan, walked up and handed me a small speaker, the kind that might get attached to a PC. He suggested I flip the switch and turn it on. When I did, the sound of a dial tone poured out, just as if I'd picked up my phone. The realism of the dial tone made me grin. Then it "dialed." Then, a busy signal! It just kept going. My grin turned to a full smile. "How'd you do it?" I asked. Bob smiled and replied, "With a BS2, of course."

Look Mom, No Chips

FREQOUT is used by the Stamp (II and BS2SX) to generate tones. It's very interesting in that it can generate a single tone, or two simultaneously. By mixing tones and code, we can create some neat sounds and sound effects. Incidently, DTMFOUT is a specialized version of FREQOUT, designed to generate standard telephone "touch" tones.

The only way to appreciate this project is to run it. Note that FREQOUT can drive a high impedance speaker through a capacitor, but you'll get much better sound (and volume control) by using a small amplifier. If you don't have one handy, you can build the circuit in Figure 1 for a few dollars in parts.

Sounding Off

Listing 1 is the code for Bob's (with a little help from Jon) Stamp-based sound effects generator. Load it up and run it. Pretty neat, huh? Okay, let's take a look at the code to see how all the sounds were created.

Since the declarations section contains no magic, jump right down to the code at Dial_Tone, the first effect. The telephone company's dial tone is actually the combination of two frequencies: 350 Hertz and 440 Hertz. This is perfect for FREQOUT. We only need to specify how long to generate the tones. In our case, it will be two seconds by using 2000 for the timing parameter in FREQOUT.

Just for fun, I added a "click" sound ahead of the dial tone to give the effect of a receiver being lifted. We'll use the click again later.

After hearing a dial tone, we'll use DTMFOUT to "speed dial" a telephone number that is stored in a DATA statement. This code section starts by initializing the EEPROM pointer to the phone number that we want to dial. One-by-one, we will read a digit, stopping when we read a zero from memory. You'll note that the phone numbers are actually stored as ASCII strings. This makes them very easy to read in the listing. To convert an ASCII character to the decimal value required by DTMFOUT, we subtract 48 ("0") from the ASCII value.

DTMFOUT generally expects the digits zero through nine, so we check to make sure that the current character is a digit that can be dialed (character >= "0"). If the character is not in the valid "dialing" range (as would be the case for "-"), the DTMFOUT command is skipped and we retrieve the next character from EEPROM. If the character can be dialed, our DTMFOUT line "presses the button" for 200 milliseconds and inserts a 150 millisecond break afterward.

Be careful with your phone near this project. If you hold the microphone element of your phone near the speaker when the DTMFOUT demo is running, the number will be dialed. Don't believe me? Give it a try ...

If you do decide to create your own dialer from a Stamp, be aware that telephone company standards require a minimum of 50 ms for the DTMF tone with a minimum inter-digit pause of 45 ms. You'll probably want to use longer DTMF tones, especially if your telephone line is noisy and you're using acoustic coupling (from speaker to phone).

The next sound effect is a telephone busy signal. This effect is created by mixing tones of 480 and 620 Hertz. The tones last for 400 milliseconds and are separated by a 620 millisecond break. FREQOUT embedded in a FOR-NEXT loop takes care of creating this effect.

For the sake of continuity through the demonstration, I inserted another dialing demo. It works exactly like the first, except that this one points at a different telephone number. In a dialer application, this code could be converted to a generalized subroutine that takes the EEPROM address of the number to be dialed before being called.

After the second number is dialed, we hear the phone ring. Once again, this is very simple with the FREQOUT command. The ring back tone (which is actually created by the telephone

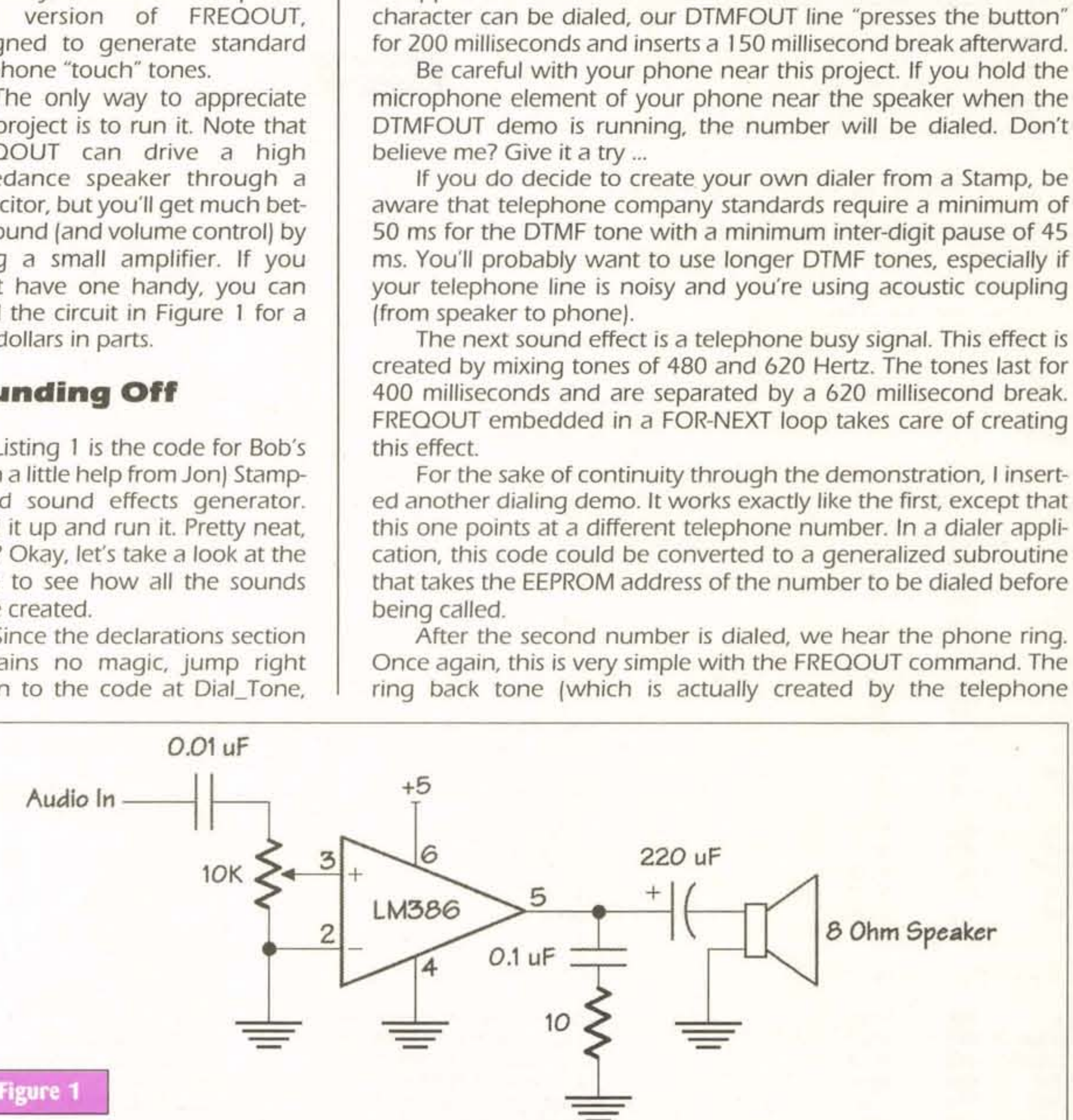


Figure 1

company's central office, not the phone you're calling) is a mixture of 440 and 480 Hertz tones for two seconds, followed by a four-second gap.

Okay, we can't use FREQOUT to simulate someone answering that phone call, so we'll play a little tune instead. Music generation is probably the most popular use for FREQOUT.

The tune is stored in three LOOKUP tables. The first table contains the notes and rests that were defined earlier. Note that sharp notes are designated by the note followed by a small "s." We can't use the "#" sign like on music since this is not a valid character for constants.

The second table contains the octave for the corresponding note in the first table. When creating your own songs, you must take care that each of the tables have the same number of entries.

The final table contains the duration for each note. Since all notes less than a whole note (N1) are derived from the whole note value, you can change the timing of a song very easily by changing the value of the whole note.

With all of the information about a note collected (tone, octave, and duration), the Play1Note subroutine is called to make the sound. This routine calculates the proper frequency of the note for the octave specified, then uses FREQOUT to play it. For musical notes, each octave represents a doubling of the note's frequency. The left shift operator (<<) makes calculating the frequency for the specified note easy.

There is an additional subroutine called WarbleNote that I lifted from the Stamp manual. This routine takes the first tone, then creates a second that is of a slightly lower pitch. The closeness in pitch between the two tones creates an interesting warbling effect.

There's no need to describe the details of the rest of the program. Each of the effects is simple and uses FREQOUT as we already have. Just a word of warning: If you're running through an amplifier, be sure to have it turned down low before it hits the Howler demo. It's amazing how the combination of a couple of tones can be incredibly annoying. This is a great routine for a Stamp-based alarm system.

More on Music

The CONstants declarations in the program contain comments for the ideal frequency of each note in the scale for the first octave. I put that information in the code for those who may want to create more accurate music notes than what is possible with Play1Note and Play2Notes.

Remember that the Stamp uses integer mathematics (whole numbers only). Right off the bat we're at a slight disadvantage because we have to round the first octave tones to integers. The rounding problem gets compounded with Play1Note. Every time we double the frequency of a note (go up an octave), the rounding error gets bigger. It's possible, then, for the higher octave notes to be out of tune.

The problem can be fixed by creating a table of CONstants for all the notes you might want to use. To convert the first octave tones, use the following multipliers, then round to the closest integer value.

2nd: tone x 2
3rd: tone x 4
4th: tone x 8
5th: tone x 16
6th: tone x 32
7th: tone x 64
8th: tone x 128

For example, B in the 8th octave would be 61.735 x 128 = 7902.08, which rounds nicely to 7902.

What might you do with Stamp music? How about a custom doorbell that plays your favorite holiday song?

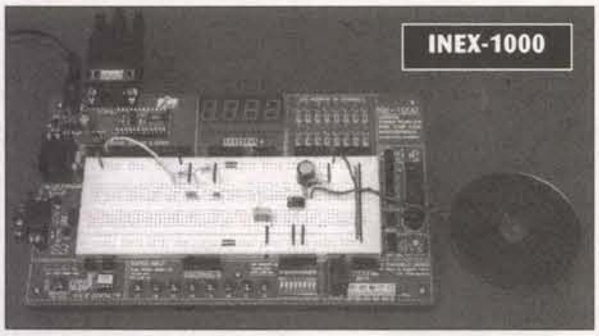
Prototyping Paradise

A recent addition to the Parallax product line and now my favorite

Listing 1

```
' =========================================================================
' Program... SOUNDS.BS2
' Author.... Robert Jordan (modified by Jon Williams)
' Started... 03 SEP 2000
' Updated... 07 SEP 2000
' =========================================================================


' -----[ Program Description ]---------------------------------------------
'
' This program demonstrates the versatility of the Stamp 2 FREQOUT
' command.


' -----[ Revision History ]------------------------------------------------
'


' -----[ I/O Definitions ]-------------------------------------------------
'
Spkr    CON     15                      ' speaker port


' -----[ Constants ]-------------------------------------------------------
'
R       CON     0                       ' rest
C       CON     33                      ' ideal is 32.703
Cs      CON     35                      ' ideal is 34.648
D       CON     37                      ' ideal is 36.708
Ds      CON     39                      ' ideal is 38.891
E       CON     41                      ' ideal is 41.203
F       CON     44                      ' ideal is 43.654
Fs      CON     46                      ' ideal is 46.249
G       CON     49                      ' ideal is 48.999
Gs      CON     52                      ' ideal is 51.913
A       CON     55                      ' ideal is 55.000
As      CON     58                      ' ideal is 58.270
B       CON     62                      ' ideal is 61.735

N1      CON     500                     ' whole note
N2      CON     N1/2                    ' half note
N3      CON     N1/3                    ' third note
N4      CON     N1/4                    ' quarter note
N8      CON     N1/8                    ' eighth note


' -----[ Variables ]-------------------------------------------------------
'
x       VAR     Word                    ' loop counter
note1   VAR     Word                    ' first tone for FREQOUT
note2   VAR     Word                    ' second tone for FREQOUT
dur     VAR     Word                    ' duration for FREQOUT
oct1    VAR     Nib                     ' octave for freq1 (1 - 8)
oct2    VAR     Nib                     ' octave for freq2 (1 - 8)
ee      VAR     Byte                    ' EEPROM pointer
digit   VAR     Byte                    ' DTMF digit
clkDly  VAR     Word                    ' delay betweens "clicks"


' -----[ EEPROM Data ]-----------------------------------------------------
'
PN1     DATA    "972-555-1212",0 ' a stored telephone number
PN2     DATA    "916-624-8333",0 ' another number


' -----[ Initialization ]--------------------------------------------------


' -----[ Main ]------------------------------------------------------------
'

Main:
  DEBUG CLS
  DEBUG "Robert Jordan's BS2 Sound Demo",CR
  DEBUG "-----------------------------",CR


Dial_Tone:
  DEBUG "Dial tone",CR
  FREQOUT Spkr,35,35                    ' "click"
  PAUSE 100
  FREQOUT Spkr,2000,350,440             ' combine 350 Hz & 440 Hz


Dial_Phone1:                            ' dial phone from EE
  DEBUG "Dialing number: "
  ee = PN1                              ' initialize ee pointer
GetNum1:
  READ ee,digit                         ' read a digit
  IF digit = 0 THEN Phone_Busy          ' when 0, number is done
  DEBUG digit                           ' display digit
  IF digit < "0" THEN IncEE1            ' don't dial non-digits
  DTMFOUT Spkr,200,150,[digit-48]       ' dial digit (convert from
ASCII)
IncEE1:
  ee = ee + 1                           ' update ee pointer
  GOTO GetNum1                          ' get another digit


Phone_Busy:
  PAUSE 1000
  DEBUG CR, " - busy...",CR
  FOR x = 1 TO 8
    FREQOUT Spkr,400,480,620            ' combine 480 Hz and 620 Hz
    PAUSE 620
  NEXT
  FREQOUT Spkr,35,35                    ' "click"
```

STAMP APPLICATIONS
SOUND IDEAS THE BASIC STAMP II



Stamp developing tool is the INEX-1000 prototyping and development board. The INEX-1000 holds a BS2 (or BS2-SX), has a five-volt power supply (good for about an amp), and a full-sized, solderless breadboard that is surrounded by a variety of Stamp-useful components:

- Four seven-segment LEDs (common cathode)
- 16 LEDs with current limiters (active high)
- A 14-pin IDC socket for a parallel LCD
- Piezo speaker
- 10K pot
- Four high-current outputs (12 VDC, through ULN2003)
- An eight-position SIP with pull-ups
- Eight push buttons (one side connected to ground, the other floats)
- A pulse generator (1 Hz, 10 Hz, 100 Hz, 1 kHz)
- An RS-232 interface with DB9 connector

The INEX-1000 includes a 12-volt "wall wart" supply and a parallel LCD module that's ready to plug into the IDC connect. You add a Stamp, some 22-gauge solid wire, any interfacing components you might need, and you're ready to develop.

In the photo, you can see the INEX-1000 with an LM386 amplifier built in the solderless breadboard.

For those of you "lurking" this column and, perhaps, the Stamp mailing list that haven't bought a Stamp yet because you didn't know what else you might need, Parallax is building a solution for you. Just in time for the holidays, Parallax will release a kit called "StampWorks" that includes the INEX-1000, a BS2, several electronic (i.e., shift registers, LED drivers) and mechanical parts (servo and stepper motors), tools, wire, documentation with over 35 experiments ... short, the works: everything you need to learn to program the BS2 for a variety of applications.

The kit is targeted for the $300.00 range — a tremendous value considering all that is included in the kit. Stay tuned to the Parallax website for the final release date and details.

Until next time, Happy Stamping. **NV**

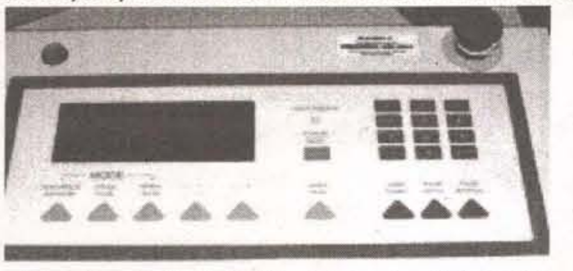
Resources:

Jon Williams
3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

Parallax
599 Menlo Drive, Suite 100
Rocklin, CA 95756
(888) 512-1024
www.parallaxinc.com


```
Dial_Phone2:
  DEBUG "Calling Parallax: "
  ee = PN2
GetNum2:
  READ ee,digit
  IF digit = 0 THEN Phone_Rings
  DEBUG digit
  IF digit < "0" THEN IncEE2
  DTMFOUT Spkr,200,150,[digit-48]
IncEE2:
  ee = ee + 1
  GOTO GetNum2


Phone_Rings:
  PAUSE 1000
  DEBUG CR, " - ringing"
  FOR x = 1 TO 4
    FREQOUT Spkr,2000,440,480             ' combine 440 Hz and 480 Hz
    PAUSE 4000
  NEXT


Camptown_Song:
  DEBUG CR,"Play a camptown song",CR
  FOR x = 0 TO 13
    LOOKUP x,[ G, G, E, G, A, G, E, R, E, D, R, E, D, R],note1
    LOOKUP x,[ 4, 4, 4, 4, 4, 4, 4, 1, 4, 4, 1, 4, 4, 1],oct1
    LOOKUP x,[N2,N2,N2,N2,N2,N2,N2,N2,N2,N1,N2,N2,N1,N8],dur
    GOSUB Play1Note
  NEXT


Howler:
  DEBUG "Howler -- watch out!!!",CR
  FOR x = 1 TO 4
    FREQOUT Spkr,1000,1400,2060           ' combine 1400 Hz and 2060 Hz
    FREQOUT Spkr,1000,2450,2600           ' combine 2450 Hz and 2600 Hz
  NEXT


Alt_Dial_Tone:
  DEBUG "Alternate Dial Tone",CR
  FREQOUT Spkr,5000,600,133               ' combine 600 Hz and 133 Hz


Fast_Busy:
  DEBUG "Fast Busy signal",CR
  FOR x = 1 TO 10
    FREQOUT Spkr,200,480,620              ' combine 480 Hz and 620 Hz
    PAUSE 310
  NEXT


' *************************
' Additional sounds from Jon
' *************************

Roulette_Wheel:
  DEBUG "Roulette Wheel",CR
  note1 = 35                              ' frequency for "click"
  dur = 5                                 ' duration for "click"
  clkDly = 250                            ' starting delay between clicks
  FOR x = 1 TO 8                          ' spin up wheel
    FREQOUT Spkr,dur,note1                ' click
    PAUSE clkDly
    clkDly = clkDly */ $00BF              ' accelerate (speed * 0.75)
  NEXT
  FOR x = 1 TO 10                         ' spin stable
    FREQOUT Spkr,dur,note1
    PAUSE clkDly
  NEXT
  FOR x = 1 TO 20                         ' slow down
    FREQOUT Spkr,dur,note1
    PAUSE clkDly
    clkDly = clkDly */ $010C              ' decelerate (speed * 1.05)
  NEXT
  FOR x = 1 TO 30                         ' slow down and stop
    FREQOUT Spkr,dur,note1
    PAUSE clkDly
    clkDly = clkDly */ $0119              ' decelerate (speed * 1.10)
  NEXT


Computer_Beeps:                           ' looks great with randmom LEDs
  DEBUG "50's Sci-Fi Computer",CR
  FOR x = 1 TO 50                         ' run about 5 seconds
    RANDOM note1                          ' create random note
    note1 = note1 // 2000                 ' don't let note go to high
    FREQOUT Spkr,50,note1                 ' play it
    PAUSE 100                             ' short pause between notes
  NEXT

  DEBUG CR,"Sound demo complete."

  END


' -----[ Subroutines ]-----------------------------------------------
'
Play1Note:
  note1 = note1 << (oct1-1)               ' get frequency for note + octave
  FREQOUT Spkr,dur,note1                  ' play it
  RETURN


Play2Notes:
  note1 = note1 << (oct1-1)               ' get frequency for note + octave
  note2 = note2 << (oct2-1)               ' get frequency for note + octave
  FREQOUT Spkr,dur,note1,note2            ' play both
  RETURN


WarbleNote:
  note1 = note1 << (oct1-1)               ' get frequency for note + octave
  note2 = note2 - 8 MAX $7FFF             ' create slightly lower frequency
  FREQOUT Spkr,dur,note1,note2            ' play warbled
  RETURN
```

FABULOUS, NEW, YAG LASER SYSTEMS PROVIDES, 100Watts, CW @1.064um, also a frequency doubled model with 60Watts or GREEN @ .532um



Laser Photonics Type: YCO-1003M, adjustable output power from 100mW to 100Watts ± 2%. Modes include: CW, Single pulse adjustable from 0.1 to 9.9 seconds in 0.1 sec increments. Repeat pulse with adjustable duration as previous and adjutable rate from 0.1 to 9.9 seconds in 0.1 sec. increments. Beam delivery via a 4 meter length quartz fiber optic. Internal fiber calibration system. LCD control panel for easy setup. Frequently used program settings can be saved to memory. Internal graphics printer. Pulsed laser diode aiming laser. Two stage microprocessor system monitoring. Key switch access with foot switch laser activation. Internal liquid to air cooling. Power required: 220VAC, single phase @40A, 60Hz. Mechanical: 38"H x 33"W x 22"D, weighs 325lbs., Wheel around cabinet. The Dual mode system in addition to the YAG specifications above includes frequency doubling on demand. The green output is Q-switched at 10KHz producing an output beam of 6mJ @ 200ns or 60W average with 2 to 40 watts delivered at the fiber. Pulse mode operation for the dual mode is different as well: Single pulse mode is adjustable from 0.1 to 600 seconds in 0.1 sec. increments. Repeat pulse mode has the same adj. pulse width and an adjustable pulse interval of 0.1 to 9.9 seconds in 0.1 sec. increments. These numbers apply to the 1.064 wavelength only. Cabinet size: 40"H x 33"W x 23"D weight 500lbs. Both models are NEW. Must ship via truck.

NEW, 100W, 1.064um, CW YAG SYSTEM....................................$15K
NEW, DUAL FREQUENCY YAG SYSTEM with 60W GREEN.......$19K

BERTAN, HIGH VOLTAGE POWER SUPPLY MODEL 315, 0-5000VDC @ 0 -5mA

Automatic current limiting & arc protection assures reliable operation. Remote output high voltage programming & high voltage operation interlock are included. Specs: Reg: ±0.001% line, 0.002% load. Temco (0 to 50°C): 50ppm per °C. Stability (after ½ hr warm up) 0.01%. Ripple: 25mV p-p. Calibrated front panel 10-turn potentiometer with 3 digit counter with resolution 0.25% of max. Programmable input for remote control of the output high voltage. 115 Vac ±10% @ 0.5A powered. Size: 11.35" W x 8.7" H x 9.7" D, weight 11 lbs. **Special, Ltd. Qty., BERTAN-315........$325ea.**

ARGON LASER POWER SUPPLY, from Spectra Physics.

We were fortunate to obtain these used and untested power supplies. Always in demand but hard to find. They can power most Argon heads up to 12AMPS. If you have an Argon head this is the least expensive way to get a power supply. Power supplies will require some repairs to be fully operational, sold As-Is. 110VAC power. Rugged anodized aluminum, housing with internal fan. Don't miss out. Limited quantity.

Holiday Special, APSX...$149ea.

SPECIALTY HIGH VOLTAGE CAPACITORS, from JENNINGS and CORNELL DUBILIER

First, we have a Jennings , CLFI-50-0030, (shown left), vacuum capacitor, rated at 50pf ± 10% @ 30KV, Size: 2.2" Diam. x 6.5"L, if that's to much for you, we have the CD, type 4CM #10-26620-01 Aluminum electrolytic, rated at 560uF @ 400VDC, Size: 1.7" Diam. x 3.1"H, vertical PC board style mounting. Both are brand new. Limited quantity.

Holiday Special, JEN-CLFI.....$99ea. or CD-560.....$3ea.

NEW !, Q - SWITCH, CRYSTAL TECHNOLOGIES, MODEL 5100

We were fortunate to obtain a small quantity of these first quality units. They were destined for use in a 100W YAG laser. See "YAG LASER above left" No specifications at press time. Water cooled. A limited number of matching RF drivers for these Q-switches are available.

Q-SWITCH...$225ea.
DRIVER.....RFMHZ-5100.$350ea.

GENERAL SCANNING, TYPE M3, CLOSED LOOP, GALVANOMETER, LASER SCANNER.

Innovative motor design coupled with an advanced capacitive position detector, provides high speed, wide angle and improved stability. Using moving magnet technology this scanner provides low inertial, rigidity and low inductance. Specs. include, +/-30° excursion, wobble: 1.5urad., Repeatability: 2urad.,Coil Res.: 4.8 Ohms, Peak current: 10Amps, Angular sensor sens.: 8.1uA/o. A high quality galvo for demanding laser displays. Galvo only you provide the drivers. Very limited quantity.

Hoiday Special, M3 GALVO..$349ea. or 2 for $649

CO2, 120Watt CW, SEALED GLASS LASER HEADS Integral Hard Sealed Mirrors, NEW!

High quality water cooled heads. Were originally designed for medical application. All models are similar in construction. Size of the model 103: 60"L x 3.2"diam., Model 135: 35"L x 3.2"diam. Power requirement, model 103, 40KV trigger with 25KV @ 10 to 30ma operating current. Model 135, 25KV trigger with 15-20KV @ 7 to 20mA operating current. These are not toys. They must conform to Class IV CDRH regulations when assembled into a functioning system. Perfect for engraving, cutting and drilling most materials. Only two available. We don't expect any more. New power supply for 35W tube, $399ea.

Limited Qty...100+Watts.....$1475., 35Watts.....$895.

NEW, SUPER 12VDC or 9VDC, POWER PACKS, fully regulated, lightweight, switchmode design.

Brand new. High quality. Compact, 9VDC @400mA unit (shown top left) Size: 2"W x 3.5"L x 1.4"H, Supplied with removeable 6ft AC line cord & attached 60" DC cable with std. tip neg. barrel plug. The 12VDC @ 700mA model (shown bottom left) Size: 2.7"W x 5.5"L x 1.5"H, Supplied with removeable 6ft. AC line cord and attached 24" DC cable with standard tip positivebarrel plug. Stock up now! Don't confuse these with cheap unregulated adapters.

Special, PWRP-6VOLT..6.50ea. or 5 for $29
PRRP-12VOLT..$7.50ea or 5 for $35

NEW, TRIPLE OUTPUT, 60W, POWER SUPPLY

Astec model: SA40-1313, outputs of +12VDC @ 3Amps, +5V @ 5Amps and -12V @ 350mA. 110VAC input. Very compact size: 3"W x 5"L x 1.3"H Perfect for many hobby applications as well as an external disk drive power supply.

Holiday Special,.....$4ea. or 6 for $20

10V @ 2.5 AH SEALED, LEAD ACID, PACK.

Each pack has 5, 2 Volt cells. 'D'size cells are arrainged as 1X5 cells. Enclosed in an ABS outer shell. (removed for photo) Perfect for high drain applications. Make custom packs of any rating. Size: 7.5"L x 2.8"H x 1.5"D

SALE! 6-five packs for $20, 40 for $99

6V@12AH SEALED, RECHARGEABLE,

New, Panasonic, LCR6V12PI. Tough to get at a discount. Very compact. Two top mounted 1/4" faston connectors. Perfect for high drain projects. Size: 5.9"L x 3.7"H x 1.9"D

2 for $20, or 10 for $89

FIVE OUTPUT POWER SUPPLY, Will power just about anything you can dream up.

New, Elpac Model 1822 fully enclosed in an attactive brushed steel and black enclosure. Industrial quality power supply with five individually fused outputs. +5VDC @ 2.5Amps,±12VDC @ 0.5Amps, ±20VDC @ 2.5Amps. Trimmer externally adjusts up to ± 15 and ± 24VDC Operates from 110VAC or 220VAC. Size: 6"H x 8"W x 16"D. **SPECIAL......$20ea. 3 for $49**

HP 6024A, AUTORANGING POWER SUPPLY, Efficient, compact and light weight.

With output of 0-60 volts at up to 10 amps amps, 200Watts max. Ten turn potentiometers provide precise control of voltage and current. Output levels can be observed on separate voltage and current meters. Front panel adjustable OVP. Also protects from over temp. and high AC line.

Reg. $895, Holiday Special...$595ea.

HP 6034A, AUTORANGING POWER SUPPLY,

With output of 0-60 volts at up to 10 amps amps, 200Watts max. All digital with dual LED displays and GPIB interface. Rack mountable. Front panel adjustable OVP. **Reg. $1495, Holiday Special.......$995ea.**

NEWPORT TRANSLATION STAGES.

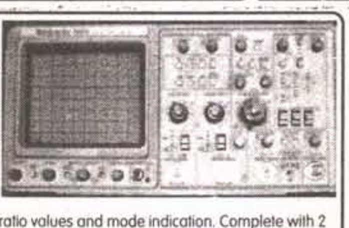
MODEL:	DESCRIPTION:	EACH
605-4	With differential Mic.	$849
605-4	With Screw Adjust	$449
600A-3	W/Micrometer Adj.	$159
270	LAB JACK	$249
RSA-2T	360 deg. Rotary Stage	$129
625A-4	Laser Holder	$149
481A	Rotary Stage	$189
M36	Translation Stage	$249
460A-XY	X-Y Translation Stage	$189
460A-XYZ	X-Y-Z Translation Stage $299	
M37	3 Axis Trans. Stage	$289
415	Vertical Trans. Stage	$129
M436	Translation Stage	$199
M150	Magnetic Mtg. Base	$129
420	Linear Trans. Stage	$69

NEWPORT, LC-075, 10X COLLIMATING TELESCOPE

The LC-075 is a general purpose laser collimator optimized for low wave front distortion at infinity. Oversized entrance aperture of 7mm for ease of alignment. Wavelength: 400-700nm, Exit aperture: 18.8mm, wavefront distortion at infinity less than 1/10 wave. Transmission: 90%. Used in excellent condition. Ltd. qty.

Newport price: $775. OUR PRICE.....$289ea.

TEKTRONIX 2465, 4 Chan., 300MHz, O'Scope, With on screen waveform stats



One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.....$2195.**

TEKTRONIX 2445, 4 Chan., 150MHz, O'Scope, With on screen waveform stats

One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.......$1295.**

TEKTRONIX 485, 350MHz,

Probably the fastest and lowest cost scope available today. Superior performance at low cost! Dual Trace, Delayed sweep 1 nS/div Sweep rate, 5mV Vert. sensitivity. Switchable input imped., 50 ohm /1meg. Package includes 2 probes, and operation manual. Six month warranty. Excellent shape.

New....$9100, Now.......$749ea.

HP5335A, UNIVERSAL SYSTEMS COUNTER

Providing true automatic measurement functionality. This system has 16 built in front panel accessible measurement functions, all available via the HPIB or manually. One of the most powerful universal counters availble. Math and statistics include averaging, mean, sample size, standard deviation, engineering units display offset scale and normalization. Matched dual inputs provide 200MHz on chan. A and 100MHz on chan. B. Nine digit resolution from 30Hz to 200Mhz. 1meg. and 50 Ohm inputs. Auto trigger and much more. All the toys in one package! Excellent.

New......$3900, Now.....$395

DC GEAR MOTOR, BUEHLER PRODUCTS, type 127K01880 ALL METAL CONSTRUCTION, HIGH TORQUE,

These are brand new, very rugged gearmotors. They offer a 5mm diameter x 9mm long, flatted output shaft, located off-center (approximately 10mm from the edge of the 35mm diameter gearbox.) Overall size: 35mm d x 73 mm L (including the shaft) with 2" red and black leads. The motors are rated at 17VDC nominal and provide the following speeds:

@VIN	I NO LOAD	RPM
12V	60mA	360
15V	62mA	457
17V	64mA	523

Holiday Special, BUEHLER 127K........$10ea. or 3 for $25

RUGGED DC MOTORS, Your choice, High power or Mini.

Larger photo is a Johnson 7500 series, 12 to 36V, 1/40HP! 6800 RPM @ 36VDC, 510mA @31 oz. in torque. 1/8"d x 3/4"L hardened, knurled shaft. Zinc plated steel body. Wt. 8oz., Size: 1.4"d x 2.5"L. Fast-on terminals for power input. **Holiday Special, Type J-7500, 4 for $10 or 25 for $49**

Smaller photo, 1.5to 6VDC, approx. 3000RPM, @ 3V, 150 mA. Size: .635"d x 1.3"L, 11 tooth, .15"d gear on shaft. Two mounting holes on face.

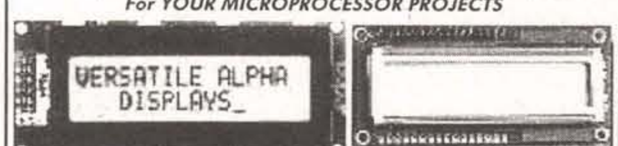
Type MINI-30, 6 for $5 or 24 for $15

EXTREMELY UNUSUAL, PITTMAN DC, SERVO MOTOR with OPTICAL ENCODER and Flex Coupled, Vacuum Seal Output Shaft.

Pittman P/N: 14204C223. All metal construction with replaceable brushes. Approximately 4087RPM no load speed. Shaft is 0.37" diam. X 1.75" Long. Overall size: 2.8" max. O.D. x 9"L not including shafts. Ball bearing outputs. Torque 14 OZ. in continuous, Peak torque, 107 OZ-in, Nominal operating voltage: 30.3 VDC, No load current 190mA, Stall Current: 19.9A, Encoder is BEI, MX-21 series. P/N:MX-213-25-100048. Quadrature with index. 1000ppr, 4000ppr quadrature. 5VDC @ 80mA powered. Square wave output TTL compatible. **Pittman Precision,.........$59ea.**

PLEASE! SEND US YOUR LIST of UNIQUE SURPLUS MATERIAL

LCD, 16X2, ALPHANUMERIC DISPLAY MODULES, For YOUR MICROPROCESSOR PROJECTS



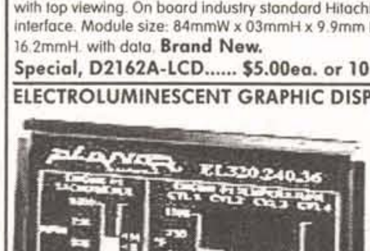
First, (shown left) from Solomon, the LM1140-SYLU, with LED backlight. Standard 16 x 2 arrangement of 5 x 7 dot matrix characters 2.95mmW x 5.56mmH with cursor. COB driver with 8 bit parallel interface. Module size: 85mmW x 36mmH, Viewing area: 63.5mmW x 15.8mmH. with data. **Brand New.**

Special, LM1140-LCD..... $7.50ea. or 10 for $6.50 or 100 for $5ea.

Second, (shown right) from Densitron, the 2162A-CT, without backlight. Standard 16 x 2 arrangement of 5 x 7 dot matrix characters 2.96mmW x 5.56mmH with cursor. TN type with top viewing. On board industry standard Hitachi 44780 driver with 8 bit parallel interface. Module size: 84mmW x 03mmH x 9.9mm D, Viewing area: 62mmW x 16.2mmH. with data. **Brand New.**

Special, D2162A-LCD...... $5.00ea. or 10 for $4.50 or 100 for $3.50.

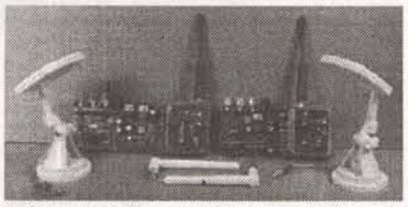
ELECTROLUMINESCENT GRAPHIC DISPLAY PANEL, from PLANAR. NEW, 320 X 128 FORMAT provides high resolution.



The Model EL4737 from Planar is a rugged, low power, electroluminescent (TFEL) flat panel display. Designed to function in extreme environments with a crisp display viewable under most lighting conditions and over a wide angle. The display color is Yellow-orange @ 585nm. The pixel aspect ratio is 1:1 with a CRT type, TTL interface. We believe these displays have an interface mode for hardware compatibility with the Hitachi HD61830B or equiv. LCD controller. The display requires 12VDC @ 500mA, Video Data or pixel information, Video clock or dot clock, Horizontal sync and Vertical sync. We have the complete system including the PS512-1 DC/DC converter module /interface. Actual power consumption is dependent on the actual text and graphics displayed. A typical mixed screen is under 2.7 watts. Panel size: 3.87"H x 8.3"W x 0.56"D, weight is 10.5oz., DC/DC Converter size: 2"H x 5.25"L x 0.75"D, weight 3oz. Active display area: 6.65"W x 2.65"H. Operating temp. 0 to +55C. Now your project can look state of the art. Brand new factory sealed. **Brand New. Special, EL4737..... $99ea.**

Write in 175 on Reader Service Card.

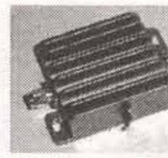
HAM GEAR FOR SALE



2.4GHz ATV — 8 channel TRANSMITTERS AND RECEIVERS. 35mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 2398, 2405, 2412, 2416, 2420, 2428, 2435, 2442 MHz. Custom frequencies are available. See ad in this section for power amplifier. **$79/each for transmitter. $79/each for receiver**. Seabrook, 972-480-0060 (Texas, CST) or E-Mail: main@480i.com Web: www.480i.com

WANTED: MILITARY capacitors, resistors, transistors, diodes, ICs, semi's, etc. Please fax/E-Mail excess lists & RFQs 818-769-1002 fax 818-769-1084. electmatind@earthlink.net & http://www.militarycomponents.com

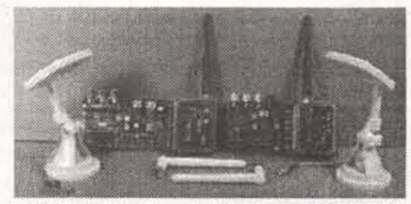
New Online Radio Forum On The www.nutsvolts.com Bulletin Board



2.4GHz POWER amplifier with power supply. 10-40 mW input, 1 (one) watt output with in-line SMA connectors and built-in heat sink. Approx. 2" x 2" x 5/8" size. Frequency range 2.3GHz-2.5GHz. **$189/each.** Compatible with all ATV product lines. See our website for more info on accessories and transmitter and receiver modules. Seabrook, 972-480-0060 (Texas, 9-6PM CST). E-Mail: main@480i.com Web: www.480i.com

WANTED: ROCKWELL-Collins HF-80 equipment, 851S-1, 237B-3 log periodic, Collins literature. Jim Stitzinger 805-259-2011, 805-259-3830 (fax), bfl-jfs@smartlink.net

TXRX 900MHz duplexers 890-960MHz 600 watt duplexers, $110/ea or $99/ea (2 or more). These are new units with circulator & load. www.amtronix.com Ph. 716-763-9104.



1.2GHz ATV — 8 channel TRANSMITTERS and RECEIVERS. 75mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 1250, 1255, 1260, 1265, 1270, 1275, 1280, 1290 MHz. Custom frequencies are available. **$79/each for transmitter. $79/each for receiver**. Seabrook, 972-480-0060 (Texas, 9-6PM CST). E-Mail: main@480i.com Web: www.480i.com

HAM GEAR WANTED

CB — SCANNERS

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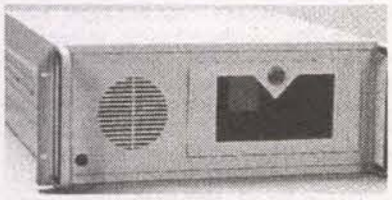

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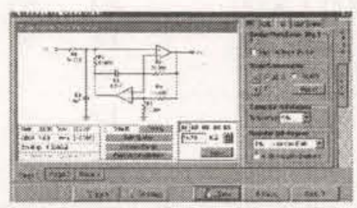

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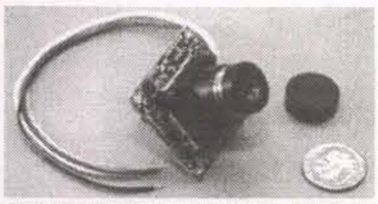

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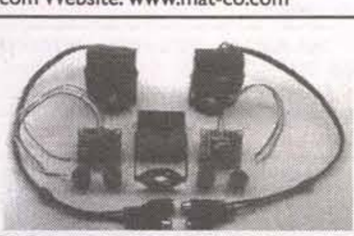

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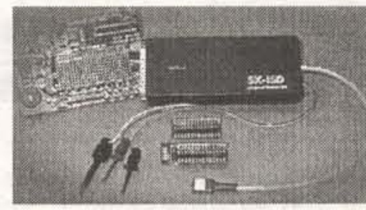

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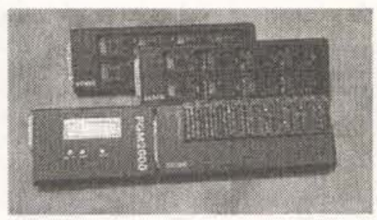

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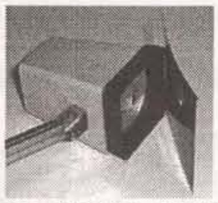

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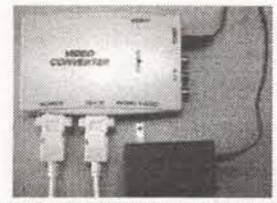

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Continued on page 55

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by Gordon West

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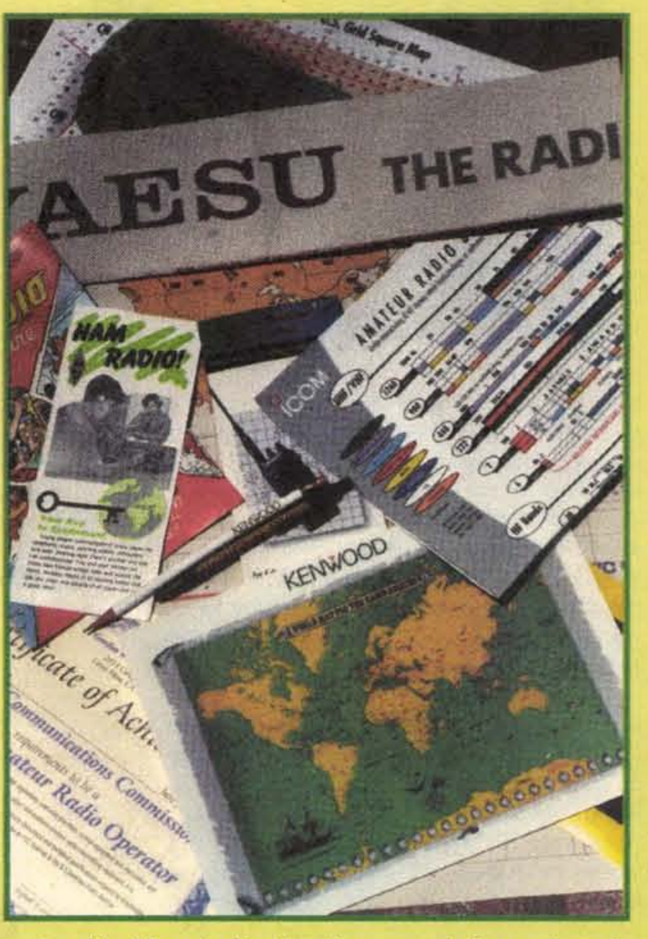


MORE CHANGES FOR THE HAM CODE TEST

Last April 15, 2000, the Federal Communications Commission (FCC) released its much anticipated report and order to restructure the amateur radio service. And for thousands of ham operators who always found learning the Morse Code difficult, the best news of amateur radio restructuring was a single 5 wpm code test for all upgrade licenses.

The new April 15 restructured rules ended the 20 wpm Extra class code test. The new rules also eliminate the 13 wpm General class code test, too. The new rules call for only a single 5 wpm code test for any ham operator wanting access to worldwide frequencies below 30 MHz.

"Probably in another five years, we may see the international Morse Code requirement completely go away," comments William Alber WA6CAX. "But until all countries agree at the World Administrative Radio Conference (WARC), still several years away, the 5 wpm code level for frequencies below 30 MHz is still on everyone's books," adds Alber.

Well, almost everyone — Japan and Mexico have some low-power operation allowed below 30 MHz without a code test, but for the most part, most other countries of the world who are members of WARC still require the 5 wpm exam.

UNFOUNDED RUMORS

After our April 15 restructuring, some hams misunderstood (or maybe never fully understood) the new rules about VHF and UHF operation *above* 30 MHz. This is where the no-code Technician class operator has full privileges, including full power output on six meters, two meters, 222 MHz, 1270 MHz, and higher — all without any code test required. This is the Element 2 Technician class examination of today — no more Novice written exam as a prerequisite, either. The new rules now make getting a ham license twice as easy!

Now, a Technician class licensee may also try for the 5 wpm code test at the same time as they take their 35-question written exam, too. If they pass the code test, the Technician class operator gains some nice Morse Code (only) privileges on 80 meters, 40 meters, 15 meters, and code, data, and voice privileges on the lower portion of the 10-meter band. Before April 15, the FCC actually had a special license for these Technician class operators called "Technician Plus." But after April 15, the license simply reads "Technician" class and it's up to each applicant who has passed the code to keep their own copy of their code-passing results. And I'm happy to say that passing the code as a Technician class operator at 5 wpm gives them operating code credit as long as they keep their Technician class license up to date. But the credit is a one-year code credit, so for an upgrade, the new Technician class operator "plus the code" may enjoy those code privileges for as long as they want, and can also use the 365 day code certificate as credit when they ultimately upgrade to General class and Extra class.

"Any Technician class operator who also passed the 5 wpm code test will certainly want to upgrade to General class as soon as possible," adds Alber, indicating the upgrade is much easier when the enthusiasm is high. "Most new Technician class operators, plus the code credit, accomplish their upgrade within weeks," smiles Alber.

Old-time ham operators who live and breathe the Morse Code were quite worried that the ham radio service was going to Satan in a handbasket because of the lessening of the code-speed requirements. Did these old-time hams get a surprise — there are now more new hams wanting to learn the code than ever before! Now that General class and Extra class only require a 5 wpm code test, *everyone getting into ham radio is learning the code*! I tell those that grumble about the code to put their efforts into teaching the code, rather than sitting back and wishing that the code test was a lot faster. A good code instructor can indeed keep the code standards nice and high on the airwaves.

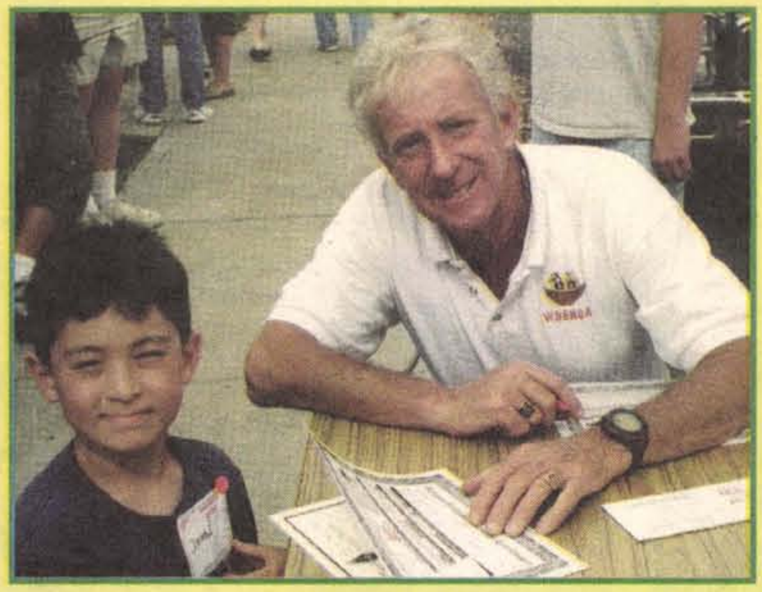
THE CODE "STANDARDS"

And, if you listen in on the airwaves, you will quickly hear that there are many different techniques for sending the Morse Code. Most good CW operators, working at a casual 8 to 10 wpm, will generate their code characters "Farnsworth method." This means they speed up the actual character of long and short sounds to approximately 15 wpm, with a nice big space in between each character to slow down the overall Morse Code word rate to 10, or 8, or even 5 wpm with big spaces, but still generating each character at 15 wpm.

At 15 wpm, the letter "C" sounds like a rhythmic "dum dee dum dee," as opposed to a

VVV VVV NI3R DE N5CRH BT RRR AND TNX SUZY. THE ANTENNA IS UP JUST 28 FEET AND IS A HUSTLER RM10 ON MY REAR BUMPER. BY THE WAY, I STILL HAVE PROBLEMS COPYING, / 467 9 KQ. HOW COPY NOW? NI3R DE N5CRH AR SK

Typical 5 wpm code test



Kids love the Morse code!!

long drawn out dash dot dash dot. At 15 wpm character rate, the letters have a distinctive rhythm, and those learning code are less apt to try to count dots and dashes.

This medium-paced character rate, with big spaces in between, has become the accepted standard by most Morse Code instructors and most examiners as the correct way to teach the code, learn the code, and send the code over the airwaves.

This Farnsworth method also became an international standard for the relative duration of elements and spacing as defined in CCITT Recommendation R.140 as adopted by the VIIth Plenary Assembly in November, 1980. A dot would be a one-unit interval, the dash a three-unit interval, and the spacing between elements one-unit intervals, and the spacing between characters 15-unit intervals, and the spacing between words 39-unit intervals.

This is the formula based on the standard word "Paris" which contains 50-unit intervals. The duration of the unit interval can actually be calculated using the formula: duration of unit intervals (in nS) = 1200 ÷ desired code speed.

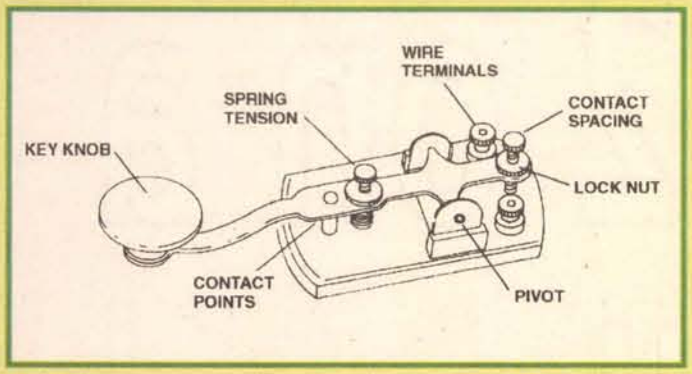
NOT SO AT SOME TEST SITES

The examinations in the United States are offered by thousands of accredited volunteer examiners. Many of these volunteer examiner "contact persons" will use code tapes from their volunteer exam coordinator, and both the ARRL and the W5YI VEC construct their audio cassettes and code computer programs to the Farnsworth method. But some other (luckily, only a few) volunteer examiner coordinators and individual volunteer examination team leaders may simply speed up or slow down the computer or tape player to adjust for an overall word rate. This means taking a 13 wpm or 20 wpm code tape, and slowing it down to 5 wpm, makes the letter "A" sound like a medium-length dot and an extraordinarily long dash. This slow-code method would make the 5 wpm code test sound like the tape machine was getting real, real low on battery juice.

And then there was another testing team that felt all hams should know the code at 25 wpm character rate, with major long spaces in between each letter. This sounded a little bit like automatic weapon fire, and this ultra-fast Farnsworth was having devastating results down at the examination room.

But keep in mind that examinations are given by fellow ham radio operators who don't get a penny for spending a day doing a lot of paperwork, handling all sorts of upgrade headaches, explaining the new ULS and CORES system, and just doing a ton of work to help keep the ham service growing. The last thing these men and women need is someone telling them their code characters are way too fast or way too slow. And these volunteer examiners also would not appreciate local hams "shopping" the test sessions to see whether or not it might be a super easy exam with multiple-choice questions

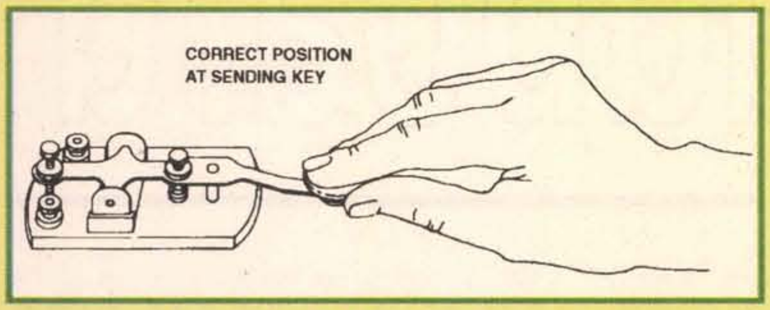
Code paddles, lower right!



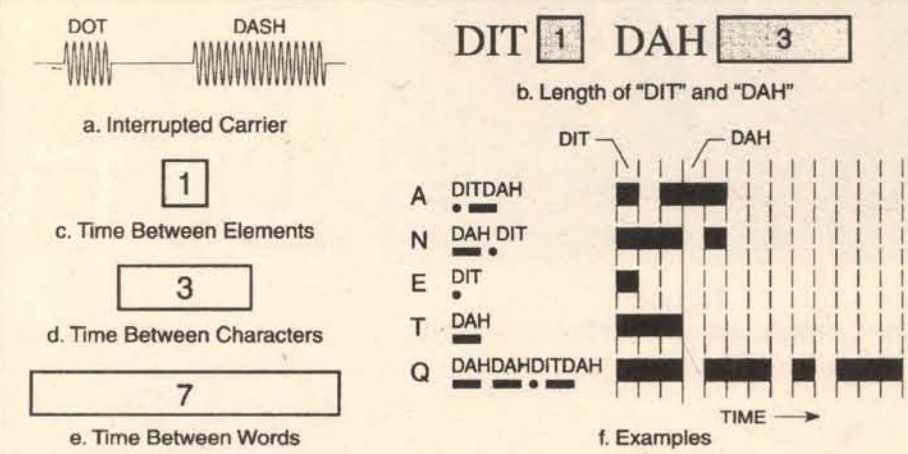
CODE KEY

License Class	Code Requirement
Technician	No code test required. Optional 5-wpm code test provides permanent operating privileges on HF worldwide frequencies. Exam credit for upgrade to General Class good for 365 days.
General	5 wpm, receiving plain language text
Extra	5 wpm, receiving plain language text

Code tests in the Amateur Radio Service.



SENDING POSITION



Time Intervals for Morse Code

and answers, or simply fill in the blanks. There were also reported exams where one minute of perfect copy was required, and after the exam was over, the applicant could NOT go back and spruce up his or her copy.

NEW CODE GUIDELINES

This winter, volunteer examiner teams throughout the country will now be working with revised standards to make the Morse Code exam sound pretty close the same at any different test session. Upcoming Morse exams would specifically use the Farnsworth method where characters are sent faster than the overall speed, and additional spaces added between characters, words, and sentences.

"Farnsworth character speed would be in the range of 13 to 15 wpm, with an audio pitch of between 700 and 1,000 Hertz," comments the National Council of Volunteer Exam Coordinators in their revised Morse testing standards news.

"Under the revised standards, examinees would have to show 25 character-count solid copy on their test sheets, or successfully answer 7 out of 10 questions of a fill-in-the-blank quiz on the sent text." This means shopping around for a multiple-choice exam will be futile within the next few months — everyone will go to fill in the blanks. "This plan would bar the use of multiple-choice tests for Morse Code testing," adds the NCVEC.

Sure, multiple-choice code tests may help you discover partial copy that can be turned into correct answers, but in all of the code tests I have administered and have seen, an applicant usually has plenty of copy to figure out any fill-in-the-blank question, or not enough copy that even multiple choice could help them get through. At 5 wpm, you are either prepared to pass the code test, or you are totally unprepared to make the grade.

And despite the standardization of the 5 wpm code exams, there will still be pitfalls to watch out for when choosing where to take the code test. If you find an examination group using headphones, chances are the headphones are probably hooked into a nice deluxe audio player or computer, and the code will sound pure. But if the code test is administered over a home-brew code tape recorded and played back over a little $29.95 cheapo boom box, chances are the echoes, hums, and no-headphone-distractions in the exam room will make it a challenge to get through 5 wpm.

But again, I salute all testing teams regardless of what type of equipment they are using for the time they spend in helping the ham service grow. These are volunteers, and they are not paid for the hours it takes to conduct and do the paperwork of an exam session.

You still may have time to find a multiple-choice code test before all testing teams switch over in July, 2001, at the latest. If you have practiced numerous code cassettes, computer code programs, code CDs, and have copied Morse Code over the airwaves, chances are you're going to do just great on your upcoming test — whether it is fill in the blanks or multiple choice. And once you pass that 5 wpm code test with a valid amateur license, you are all set to upgrade to General, and then to the highest amateur radio license — Extra class — still based on that one code-test-passing exam at 5 wpm! **NV**

by Al Williams

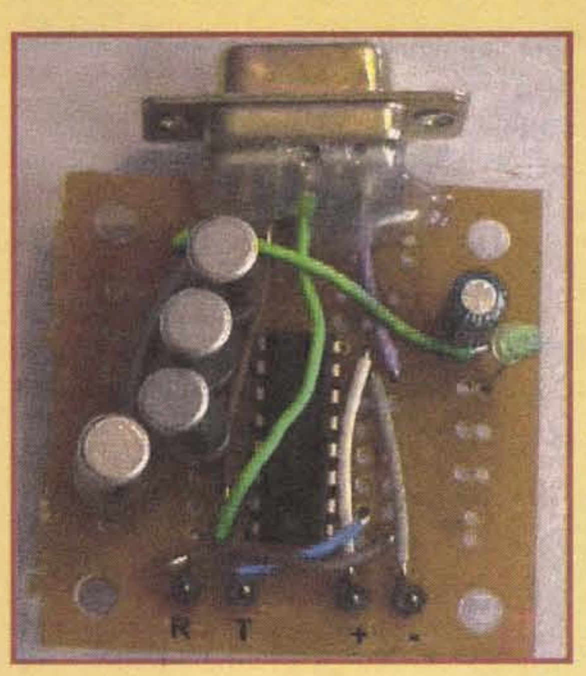


Figure 1.
The completed converter assembly.

RS-232 on a Breadboard

It is no secret that I'm a better designer than a builder. It seems to take me a lot more effort than most people to make a neat-looking project. That's why I'm sold on breadboards. A breadboard lets you try circuits, tear them apart, and rebuild them with no difficulty.

The only problem with breadboards is that not everything fits easily on a breadboard. One thing I always need on a breadboard is an RS-232 connector. Of course, most of the time, I also want to convert that RS-232 connection to TTL levels, so I need a MAX232 or similar chip to do the conversion.

I used to use wires soldered to a DB9 connector, but the wires pull out of the breadboard easily if you connect a cable to it. Besides, I got tired of building that same old MAX232 circuit over and over again. I finally found a better solution — I built a small board and arranged to make it plug into the breadboard. Of course, you could make your own PC board, but that's a lot of work for a simple project like this, so I turned to a universal PC board sold by RadioShack (part #276-159).

The Plan

The idea is to use some pins from a .1" header to convert some of the holes at the edge of the board into a breadboard connector. The board is thin enough to squeeze between the rows of pins on a standard DB9. A little hot glue will secure the connector to the board. When you are done, you'll have a ready-made RS-232 to TTL converter that will plug right into your breadboard (see Figure 1).

I considered using a right angle header so that the board would stand up and consume less space on the breadboard. However, I was worried that the strain with a cable plugged in would be too great, so I decided to use straight pins and let the module lay flat against the breadboard.

I've used this board with many BASIC Stamp projects. The BASIC Stamp can use any pin as an RS-232 input or output. However, the levels are nominally 0 and 5V. RS-232 levels are usually around ±12V and at least ±5V. Many PCs (and other RS-232 devices) will recognize 0 and 5V levels even though that is out of the RS-232 range. Also, you can use a simple dropping resistor (as explained in the Stamp manual) to receive directly from an RS-232 port. However, some ports won't work this way and you lose a lot of the benefits of RS-232 (for example, noise immunity) by taking this short cut method.

There are line driver and receiver chips that will convert RS-232 to and from TTL, but many of these (like the venerable 1488 and 1489 chips) require a + and - 12V supply. Many projects today don't have 12V available and very few have -12V. Luckily, Maxim's MAX232 family of projects makes the connection simple. These parts use a DC-to-DC converter to convert a single 5V supply into RS-232 compatible voltages.

The MAX232 — the part used in my implementation of this project — requires a few 1uF capacitors. You can also use a MAX232A, which requires smaller .1uF capacitors. The MAX233 costs a bit more (and is harder to find), but it requires no external parts at all. Space isn't a big issue for this project, so I used the MAX232. However, you could substitute either of the other parts with just a few changes.

I used an LED as a power light so I could be sure I had the power connected properly. Since the board doesn't have much space, I used a small 5V LED. These LEDs have an integrated dropping resistor, so you can connect them directly to 5V. If you can't find one of these, you could make your own, or use a blue LED (blue LEDs typically use 5V directly). Simply cut one lead of the LED very short and solder a correctly-sized resistor (for example, a 470 ohm unit) to the short lead. Trim the other end of the resistor lead to be flush with the longer lead and dress the exposed wires with heat shrink tubing. This will be a bit more awkward to mount, however, so you are better off if you can find an LED with the resistor built in. Of course, the LED is completely optional — it only lets you know that you've powered up the board.

Construction Details

The first task is to prepare the PC board. Split the board in half (it is precut, so a good twist will snap it right in half). The two halves of the board are identical, so just put one aside and use the other one. You need to use an awl, an X-Acto knife, or a Dremel tool to cut a few of the pads clear. Make the cuts where the red lines appear in Figure 2.

Next, take the pin header and match it to the outside holes in the four pads you cut free near the top of the board. With a pair of pliers, carefully remove the pins that don't fit in the holes. The holes are on a .2" grid and there is a blank space in the center, so you should be left with four of the eight pins. Next, place the pins on a flat hard surface and push so that the one end of the pin is flush with the plastic strip. Drop the strip into the outside holes on the component side (non-copper side) of the board. Solder the pins on the foil side with a minimum of solder — you want the maximum amount of pin left exposed. These are the pins that will plug into the breadboard so don't cut them! After soldering, you can trim the excess plastic from the component side of the board, although that is not necessary.

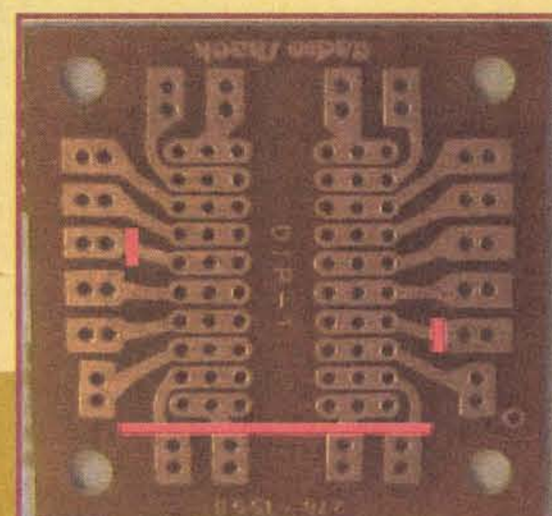


Figure 2. Make cuts where indicated by the lines.

Next, place some electrical tape or lacquer over the RadioShack logo. Don't cover any holes, although you will only use one in this area. Wedge the DB9 so that the board and tape are between the two rows of pins. It will be a tight fit. Make sure pins 1-5 are on the component side

of the board and 6-9 are on the foil side. Generously apply hot glue or epoxy to secure the connector to the foil side of the board. Later, when you know the board works, you'll do the same to the other side, but for now leave the DB9's pins 1-5 open so you can solder to them.

The MAX232 is oriented so that pin 1 is closest to the DB9. Solder the chip on the board (you could use a socket, but I didn't). For ease of reference, consider that the left hand pins start at -1 and go down. That way pin 1 of the MAX232 is in pin 1 of the board. The two holes above the chip on the right-hand side are 17 and 18, then. Therefore, the board's pins are numbered from -1 to 18. Also, consider that each pin has five holes – three near the IC itself, and two on remote pads. Starting at the innermost holes (the ones near the IC), call these holes A through E. So the IC's pin 1 is in hole A1. Pin 16 is in A16. The pin headers are in holes E7, E8, E9, and E10.

Connect a wire from the pin at E10 to B15. This is the ground connection. Wire from E15 to E0. Wire from C15 to pin 5 of the DB9. Place the - lead of capacitor C5 into D15 and the + lead into D16. The LED's + lead goes to E16 and the - lead goes to E14. Fold the - lead over to E15 and solder on both pads. E14 is isolated, so this won't ground out pin 14 of the IC. From D0, wire to D5. Place the + lead of a 1uF capacitor to E5. The - lead goes to E6.

Connect a wire from pin D9 to B16. This is +5V. Wire from C9 to D7 (receive) and from B10 to D8 (transmit). Connect B8 to the DB9 pin 3. Connect B7 to DB9 pin 2.

Connect a wire from pin B2 to C-1 (that is C minus 1). Place the + lead of a 1uF capacitor to B-1 and the - lead to B0. Place another 1uF cap + lead to C1 and - lead to C3. Place the final 1uF cap between C4 (+) and B5 (-).

Check all connections and capacitor polarities against the schematic. Plug the pins into your breadboard and wire the + and - connections. Quickly check pin 2 and pin 6 of the IC. You should see + and - voltages. The chip should not get hot. A hot chip or a lack of voltage on pins 2 or 6 means you have a problem. If the LED does not light, you may have just "missed" the right holes on your breadboard.

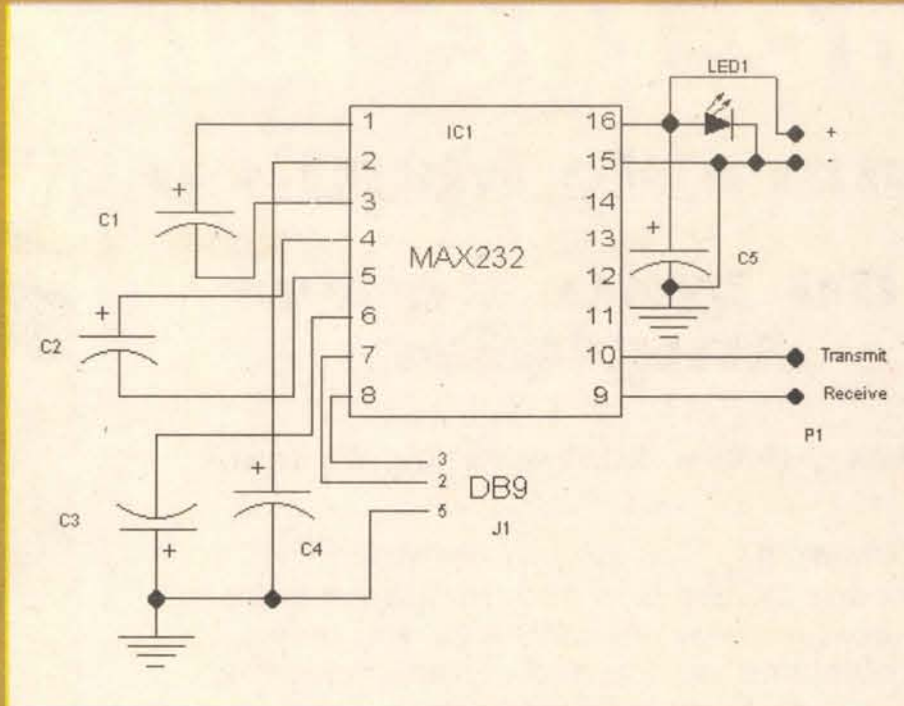


Figure 3. This is the schematic for the converter.

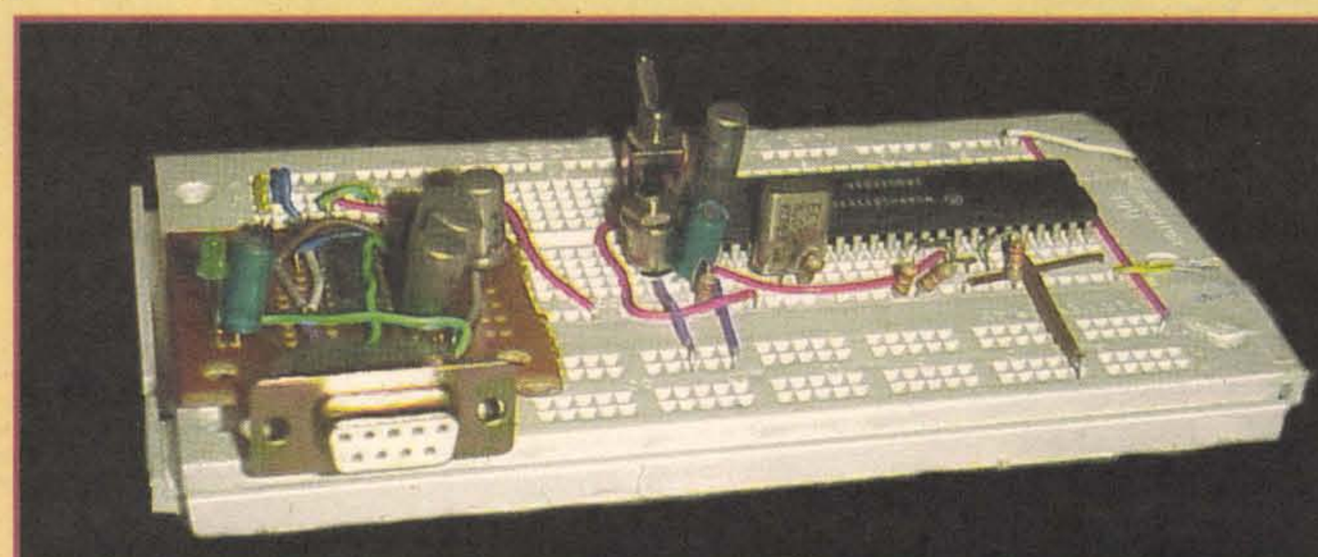


Figure 4. A project that uses the module.

Testing

One way to test this board is via loopback. With the module plugged into a breadboard (and with power applied), connect the R and T pins together with a wire. Then you should be able to connect a PC and use Hyperterminal or some other terminal program to talk to yourself. Make sure hardware handshaking is off on the terminal program's setup. Also, leave local echo off. If you can disconnect the cable and you still see what you are typing then local echo is not off! If local echo is on and everything is working, you'll see two copies of whatever you type. If local echo is off, you should see whatever you type appear in the terminal window.

Once you are sure everything works, go back and apply hot glue to the top side of the DB9 to hold it to the board.

What's It For?

Once you have the converter assembly completed, what can you use it for? As I mentioned before, the converter is ideal for use with microprocessors like the BASIC Stamp. You can also use it as a programming adapter for microprocessors that have an RS-232 bootstrap mode, like the 68HC11 (more on that next month; see Figure 4).

Of course, you don't have to stop at a 68HC11. You can build many similar modules using either a DIP-1 board or another type of universal PC board. You might build a regulated 5V supply, an A/D converter board, or an audio amplifier module – use your imagination. **NV**

Parts List

Part	Description
IC1	MAX232 or MAX232A
C1-C4	1uF 25V electrolytic capacitor (MAX232) or .1uF 25V capacitor (MAX232A)
C5	10uF 25V electrolytic capacitor
J1	DB9 Female connector with straight solder cups (RadioShack 276-1538)
P18	pin header on..1" centers
LED	15V LED with integral dropping resistor
(Optional)	
PC Board	1/2 RadioShack DIP-1 PC Board (RadioShack 276-159)

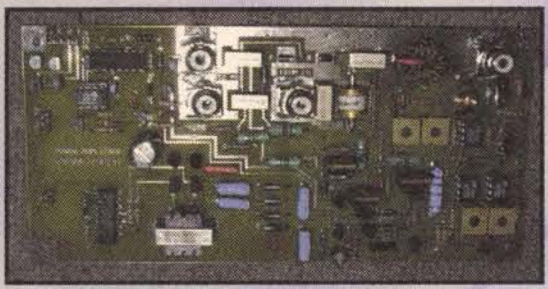
And the winner is ...

Honorable Mention

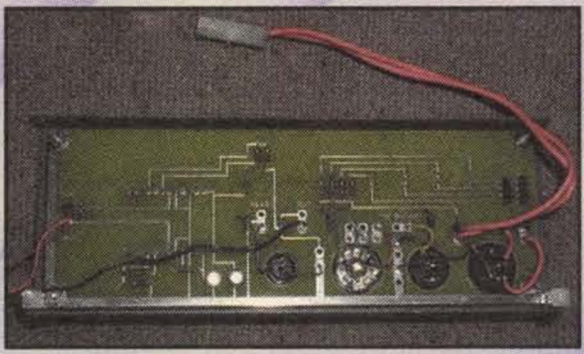
100 Watt Power Amplifier

entered by Robert E. Friess

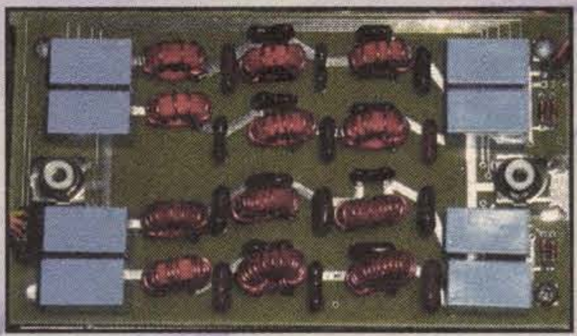
JUDGES COMMENTS: *"This project reminded us of the early traditions in ham radio where the operator built his own gear. We were impressed by the professional design and construction work."*



Control Board



Front Panel Board



Low-Pass Filter Board

This project is a power amplifier designed to cover the amateur bands from 80 meters to 10 meters, and provides an output power of 100 watts from a drive signal of approximately five watts. It is designed to be used with the Elecraft K2 transceiver.

Three ExpressPCB boards are used in this project.

RF Switching and Control Board

This board provides PIN diode switching to allow the amplifier to be switched in and out of the circuit and to sequence the operation of the input and output connections to assure that the power amplifier never receives drive power without the output load connected. In addition, VSWR measurement and load mis-match protection circuitry are provided. Also included is circuitry to detect the frequency of the drive signal so that the appropriate low-pass filter is automatically switched in line with the amplifier output.

Low-Pass Filter Board

This board provides four low-pass filters and switching relays. The filters are used to reduce the level of harmonic outputs from the amplifier. The filter appropriate for each frequency band is switched in line under control of circuitry on the RF Switching and Control board. By using carefully designed Cauer filters, only four filters are needed to cover eight frequency bands.

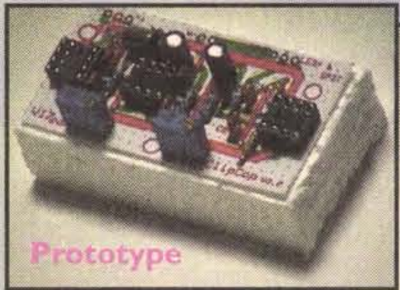
Front Panel Board

This board provides metering for forward and reflected power and interconnection for the various controls essential to the operation of the amplifier.

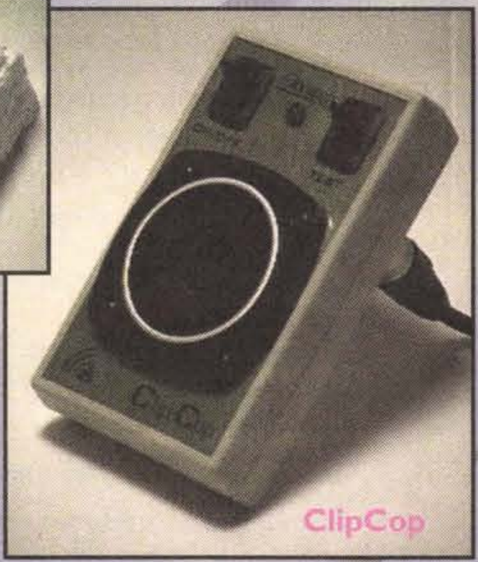
Honorable Mention

ClipCop

entered by David E. Smith



Prototype



ClipCop

JUDGES COMMENTS: *"We found this to be a very clever idea! A useful instrument built with an extremely simple circuit. The author has designed a device for determining if an audio signal is clipped due to too much gain. The cleverness comes from the use of a speaker that only reproduces high frequency sounds. Since the sharp clipping of an audio signal produces high frequency harmonics, a loud unpleasant noise is heard to indicate the gain is set too high."*

More information and construction details are available at www.vizear.com

Honorable Mention

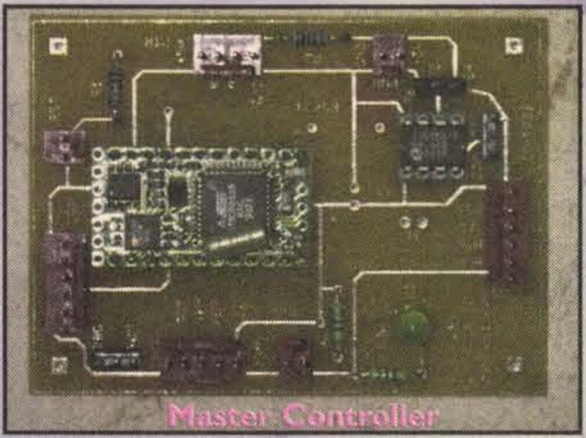
WindReader™

entered by Victor Fraenckel

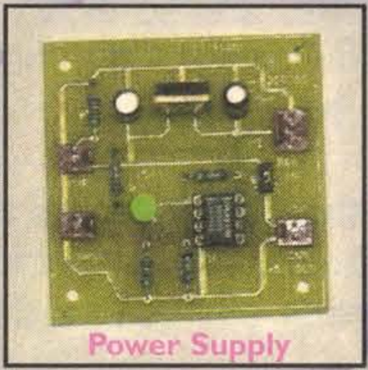
JUDGES COMMENTS: *"The author of the WindReader married a commercially available theodolite with his electronics to build an optical tracking device that logs the position of a weather balloon as it rises. His design used the off-the-shelf BASIC Stamp and V2X Compass modules, simplifying his work. His four custom printed circuit boards neatly interface all the modules together in a well-packaged design."*

The WindReader Photo 6

VX2 Compass Module



Master Controller



Power Supply

This project is a prototype of an electronic wind measuring system. It will be used to determine the wind speed and direction in the atmosphere from the surface to as high as 15,000 feet.

The measurement system consists of one optical theodolite, two BX24 microprocessors, one ADXL202 two-axis accelerometer, and one V2X Electronic Compass module. The system console consists of one LCD display unit and one 16 button keypad, a power switch, and a command switch along with two indicator LEDs, and a system serial printer. The WindReader™ is powered by a 12 volt 1.2 AH gel-cel battery.

The operator uses the theodolite to track a small, helium filled balloon, and the compass and accelerometer (acting as a two-axis tilt meter) continuously measure the azimuth and elevation angles to the balloon. The master BX24 queries the sensor BX24 for this information periodically (usually at 15 or 30 second intervals) and computes the average wind speed and direction from the vector angles obtained from two successive measurements and the balloon's ascent rate. The information; height, speed, and direction is then printed out on the system printer in near real time. The modular design allows for the reuse of the entire electronics package in other instruments.

The system is fully configurable by the user. Configuration parameters can be entered via the keypad at any time prior to the start of an observation run. This information is stored in the both computers EEPROM where it can be read by the system.

The ClipCop is a small, inexpensive handheld test device for accurately determining the maximum level before clipping for each part of a sound system. This truly allows a sound system to be 'lined-up,' thereby increasing the dynamic range of the whole sound system and reducing its inherent noise floor.

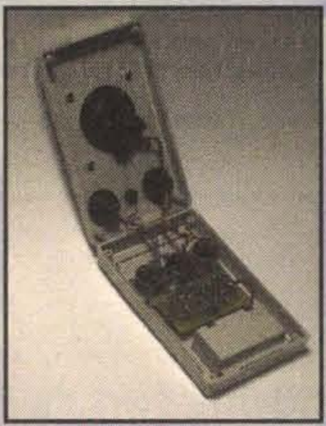
The ClipCop is comprised of an extremely low distortion sinewave oscillator tuned to 440Hz housed in the same snappy little handheld box as a piezo horn. The balanced +4dBu output of the oscillator is fed into the sound system being lined-up, and the piezo horn is connected at various points in the system so as to monitor the signal.

The piezo horn does not reproduce 440Hz very well, but it does reproduce very loudly the first odd harmonic and all the other odd harmonics above it. When the gain of any part of the system is increased and starts to clip the 440Hz test signal, the ClipCop goes from being virtually silent to reproducing a horrible raspy sound. This audible indication of the onset of clipping is even more sensitive than can be achieved using an oscilloscope.

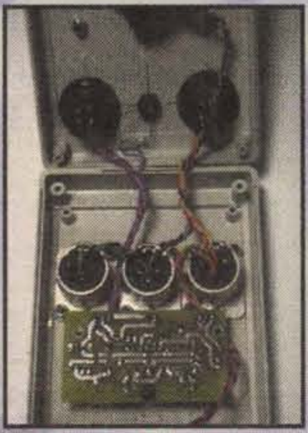
This project's original circuit board was a generic board from *RadioShack*. This meant that numerous jumper wires initially had to be soldered to the board before even the first components were mounted. This led to errors by some of my students who built the ClipCop as part of their classes in the Theatre Sound Design program at the North Carolina School of the Arts. What was needed was a custom designed circuit board.

My first foray into this world of custom designed circuit boards thankfully turned out to be fairly painless. The ExpressPCB program was very intuitive and allowed me to design what I think is a very neat board. I checked my design before submitting it by printing the layout out life size and mounting the components on the printout. In order to keep the costs down I had all the lettering done on the top copper layer, which actually looks quite professional.

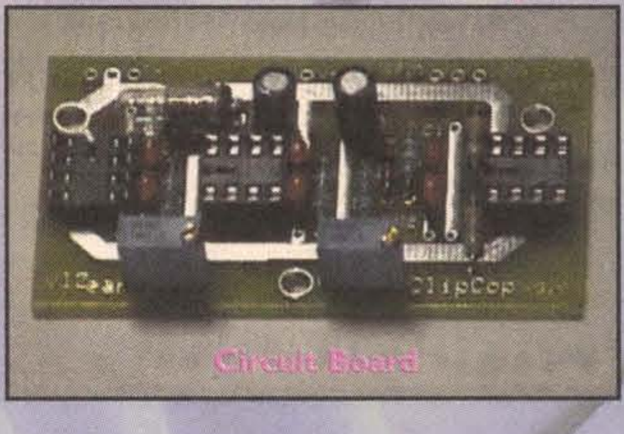
An additional benefit of the new circuit board is that it takes up less space than the original board. The dimensions of the original board left only an overall 1/10th" play between the battery compartment, circuit board, XLRs, and switches. Unfortunately, this was too close for comfort for the novice builder and resulted in quite a bit of additional filing of holes to fit everything in.



Inside View



Hook-Up View



Circuit Board

Introducing

Fuzzball's Pick of the Week

Some of you might remember Fuzzball from many years ago. He appeared monthly in *Nuts & Volts*, bringing us his pearls of wisdom in the Food for Thought column. After many years, he retired with little fanfare or fuss and quietly faded into obscurity. We had heard rumors a while back that he had passed away.

Just when our hearts and minds had grown accustomed to the absence of his fuzzy little face in the pages of *Nuts & Volts*, who shows up on our doorstep looking for work. None other than ... Son of Fuzzball! *(Prefers to go by just Fuzzball ... like his old man.)*

Since we had this new website project-thing going on, and we did need somebody (or thing?) to work at the site, and he didn't have any place else to go, we felt we owed it to Fuzzball's old man to give his boy a shot. So ... we did it. We gave him a job. A small job, but a job.

Each week, Fuzzball will search the *Nuts & Volts* archives, and select a past article or project for your enjoyment. These articles will be presented on the *Nuts & Volts* website in PDF format and can be downloaded or printed on 8½ x 11 size paper.

He's already begun building his "Best Picks" archive and who knows, if he does a good job with that, we just might give him a better job. He's already asked to sell *Nuts & Volts* tee shirts ... *but we'll have to see about that one!*

Website News

Bulletin Board

If you haven't yet heard the news, the *Nuts & Volts* website now has an online discussion board. There are forums for Radio, Robotics, Computers, Microcontrollers, and a "General" forum for any electronic topic whatsoever. If you would like to start a specific forum, let us know by sending an email to the webmaster. If we think there'll be enough interest, we'll set it up.

Book Store

It's not quite ready yet, but by the end of the month (fingers crossed), our online bookstore should be open for business. You'll be able to browse and buy online from a large assortment of electronics books. We even might add CDs and other software, if you want it. Oh yeah, and if you're a *Nuts & Volts* subscriber, you'll get a discount on any books or items you buy! *What could be better than that?*

Figure 1 — Elenco's Model SL-5 low-cost soldering station (right).

Soldering equipment available from Howard Electronics (left).

by Fred Blechman

Why build a kit?

Building Electronic Kits

Do you need to know anything about electronics? Will you learn anything about electronics? What kinds of electronic kits are there? Are they hard to build? Is it difficult to solder? Will you save time or money? Would this be a good idea for your children or grandchildren? Where can you get some of these kits? What should you look for in choosing a kit?

A "kit" is a set of parts, materials, and plans from which something is to be made or assembled. It would seem, therefore, that an "electronic kit" is just a bunch of electronic parts and materials — resistors, capacitors, tubes or transistors, wire, etc. — that you can get at any RadioShack store and merely assemble, following a schematic. For simple circuit designs, this is true. Problems arise, however, with more complex circuits.

For one thing, you may not know how to read a schematic, in which case "step-by-step" instructions and a printed circuit board would be necessary. Also, some kits require some test equipment, such as a multimeter or an oscilloscope, for properly setting some variable controls.

Building an electronic kit may direct the future of a young person's life.

Why Build a Kit?

The simplest kits do not require you to know anything about electronics, yet are a fast and fun way to become acquainted with basic electronic parts and circuits.

Forty years ago, you could pick up *Electronics Illustrated*, *Popular Electronics,* and other magazines detailing simple projects with beautifully illustrated pictorial drawings that showed every wire and connection better than any photograph.

Today, electronic components and designs have become far more sophisticated, and most of the electronic magazines seem to cater to the advanced hobbyist or experimenter. With the added technology of computers, digital logic, integrated circuits, and complex double-sided printed circuit boards thrown into the mix, it has become a challenge to find simple-to-build electronic projects. Today, you frequently have to get a complete kit because it includes some required special parts.

To assemble some kits, you'll need a background in electronics and some soldering experience; for others, you'll only need some guidance. Soldering takes a bit of practice, and is made more efficient with a "soldering station," like one shown in Figure 1.

Assuming you are a novice electronic enthusiast, you should start by building simple, fun kits that cost \$10.00 or less. You'll learn about parts and color-code markings; you'll learn about typical construction and soldering; you'll learn about printed circuit board design, and perhaps make your own. And you'll have the satisfaction of building something that works — or perhaps learn even *more* by troubleshooting and fixing a project that *doesn't* work!

Selecting a Kit

As you advance to the \$20.00 to \$50.00 kit range, you'll find yourself building devices that perform useful functions, and may not even be available as manufactured products. Generally, the more expensive the kit, the more difficult to build or troubleshoot. Be careful when selecting a kit to not exceed your capability. Some manufacturers "rate" their kits for difficulty level.

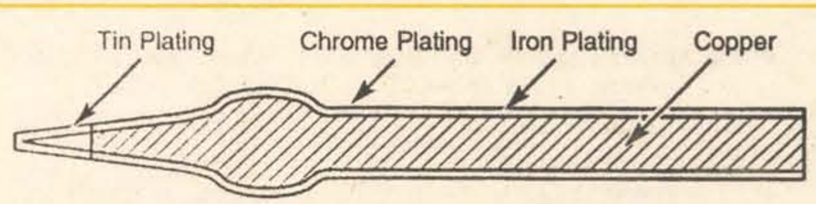


Figure 2 - Typical soldering iron tip.

You'll usually save some money building a kit, but not always. Some kits are more expensive than similar-performance assembled equipment, but you'll *learn* how a device *works* by putting a kit together! And there are many kits that provide functions that have no commercial ready-made equivalents.

Also, don't overlook this: Building an electronic kit may

Some of the Many Sources

The following are only a few of the many USA sources of electronic kits, in alphabetical order. Some are small, some are huge. Some are manufacturers, some are vendors, some are both. Some have catalogs (usually free), some don't — but you can call and ask. All have websites, many with photos or illustrations of the kits.

✔ **Alltronics**, 2300-D Zanker Road, San Jose, CA 95131
Phone: (408) 943-9773. FAX: (408) 943-9776
Website: www.alltronics.com/kits.htm
E-mail: ejohnson@alltronics.com.
See their ad on Page 58!

✔ **Cal West Supply, Inc.** (Hallbar electronic kits), 3835 R. East Thousand Oaks Blvd. #204, Westlake Village, CA 91362
Phones: (800) 892-8000 or (805) 497-9900. FAX: (805) 557-0249
Website: www.hallbar.com • E-mail: hallbar@hallbar.com

✔ ***Carl's Electronics***, P.O. Box 182, Sterling, MA 01564
Phone: (978) 422-5142. FAX: (978) 422-8574
Website: www.electronickits.com
E-mail: sales@electronickits.com
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✔ **C & S Sales** (Elenco kits), 150 West Carpenter Ave., Wheeling, IL 60090
Phones: (800) 292-7711 or (847) 541-0710.
FAX: (847) 541-9904
Website: cs-sales.com • E-mail: info@cs-sales.com
See their ad on Page 26!

✔ **Circuit Specialists, Inc.**, 220 S. Country Club Dr., Mesa, AZ 85210
Phones: (800) 528-1417, (480) 464-2485,
FAX: (480) 464-5824
Website: www.web-tronics.com
See their ad on Page 94!

✔ **Digital Products Co.**, 134 Windstar Circle, Folsom, CA 95630
Phone: (916) 985-7219, FAX: (916) 985-8460
See their ad on Page 68!

✔ **Earth Computer Technologies**
Phone: (949) 361-2333, FAX: (949) 361-2121
Website: www.flat-panel.com
See their ad on Page 64!

✔ **EKI (Electronic Kits International, Inc.)**
P.O. Box 970431, Orem, UT 84097-0431
Phone: (800) 453-1708
Website: www.eki.com • E-mail: emilio@eki.com

✔ **Electronic Goldmine**, P.O. Box 5408, Scottsdale, AZ 85261
Phone: (800) 45-0697. FAX: (480) 661-8259
Website: www.goldmine-elec.com
E-mail: goldmine-elec@goldmine-elec.com

✔ **ElectronicsUSA.com**
14270 Apple Creek Dr., Victorville, CA 92392
Phone: (760) 241-5775, (775) 416-8075
Website: www.electronicsusa.com
E-mail: info@electronicsusa.com

✔ **Electronix Express**, 365 Blair Road, Avenal, NJ 07001-2293
Phone: (732) 381-8020, FAX: (732) 381-1006
Website: www.elexp.com
E-mail: electron@elexp.com

✔ **EMAC, Inc.**, 11 Emac Way, Carbondale, IL 62901
Phone: (618) 529-4525, FAX: (618) 457-0110
Website: http://www.emacinc.com
See their ad on Page 39!

✔ **Gateway Electronics, Inc.**, 8123 Page Blvd., St. Louis, MO 63130
Phone: (800) 669-5810 or (314) 427-6116.
FAX: (314) 427-3147
Website: www.gatewayelex.com
E-mail: gateway@mvp.net
See their ad on Page 57!

✔ **Graymark International, Inc.**, Box 2015, Tustin, CA 92781
Phone: (800) 854-7393.
Website: www.graymarkint.com
E-mail: sales@graymarkint.com
See their ad on Page 55!

direct the future of a young person's life. If you have young children or grandchildren — six years old is not too young — putting a simple electronic kit in their hands, and helping them get started in electronics, could spawn another Edison, Tesla, Steinmetz, or Marconi!

Choosing Kits

If you are at a loss to find where you can get electronic kits, just type "electronic kits" (with the quotes) into a typical search engine on the Internet. I did this on www.yahoo.com and got 24,400 replies! With www.google.com I got 36,300 replies!

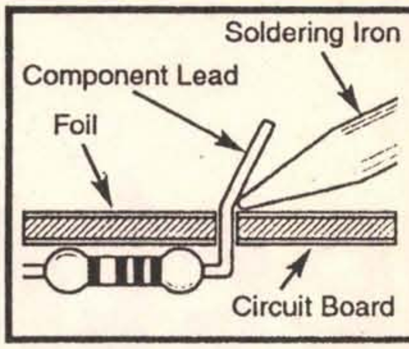

Figure 3 - Push the soldering iron tip against both the component lead and the circuit board foil.

With so many kits available, how do you choose? I suggest you look for the manufacturers of kits rather than just the vendors who sell kits from various manufacturers. Call and ask your prospective source if they make their own kits, or merely offer kits made by others. Manufacturers are best able to provide support if there are problems, such as missing parts, or to repair completed projects that don't work.

My recent book, *Simple, Low-Cost Electronics Projects*, is an 8.5- by 11-inch 206-page softcover book that has 22 projects that can be built from RadioShack parts, or kits from various vendors. The book can be ordered for $19.95 from any bookseller as ISBN #1-878707-46-9, or directly from the publisher (LLH Technology Publishing, 1-800-247-6553). Further information, the Table of Contents, and ordering, is available at www.LLH-publishing.com/catalog/books/slcep.htm.

There are so many kit sources that it becomes difficult to choose. If you are a real novice, before buying a kit, you might want to phone the source and ask the following questions: Are you the manufacturer of this kit, or just a vendor? Does it come with step-by-step instructions? Is this kit assigned a difficulty level? Are all the parts illustrated in the assembly instructions? What if I assemble the kit and it doesn't work? What if I decide it's not what I want, or it is too difficult for me — can I return it before building it?

The Building Process

Once you get the kit in your hands, you must be sure all the parts and documentation are included. A few manufacturers separate and label parts, but most don't. With the better kits, the parts are not only listed, but illustrated in the instruction or assembly manual.

I must give special mention here to LNS Technologies, which bags and identifies different types of parts (with a list of contents in each bag!), and provides an excellent step-by-step illustrated instruction booklet for assembly and operation — emulating and perhaps surpassing the legendary Heathkits of days gone by!

Once you start the assembly, you must be very careful about how you place some parts. Transistors, diodes, light-emitting diodes (LEDs), some capacitors, integrated circuits (ICs), transformers, and some other parts have to "face" in the proper direction, as shown in the kit parts layout diagram. You must also be sure the proper part value is in the correct place! All it takes is one part improperly placed — the wrong value, or facing the wrong direction — and the circuit probably won't work, and may destroy itself!

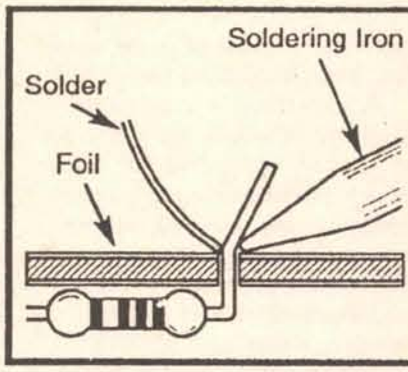

Figure 4 - Apply solder to the other side of the component lead.

Generally, if you are working with a quality printed circuit board, the parts placement and orientation is printed on the component side of the board. There may also be some printing on the foil side of the board to help guide you. Some of the more complex kits use dou-

ble-sided boards; that is, with foil and solder pads on both sides, and holes that are plated-through the holes.

When placing parts on the circuit board, there may be "jumpers" required. These are

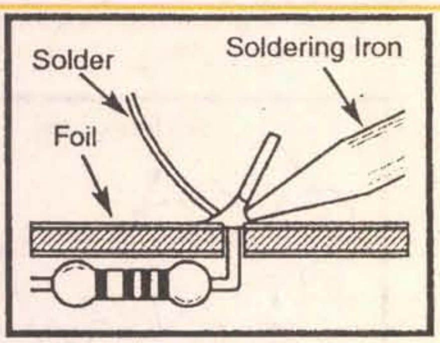

Figure 5 - Allow the solder to flow around the connection.

either plain wire or insulated wire with the insulation removed at the ends. If jumpers are required, solder them in place first. Then install small parts, working your way up to the larger parts.

Most better kits provide sockets for ICs, since they are very difficult to unsolder if misplaced, defective, or oriented the wrong way.

Soldering

Some kits might only have 10 or 20 solder connections, but some have over 200! One of the most common causes of a kit malfunctioning is one or more bad solder joints.

A poorly soldered joint can greatly affect small-current flow in circuits, and can cause equipment failure. You can damage a printed circuit board (PCB) or a component with too much heat, or cause a "cold solder joint" with too little heat. Sloppy soldering can cause a "bridge" between two adjacent printed circuit paths, preventing the circuit from functioning, or

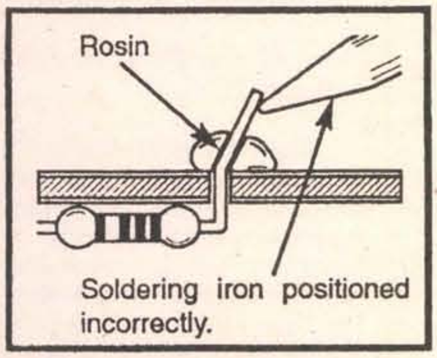

Figure 7 - Don't put the solder iron tip up on the component lead. Wrong!

causing a disastrous short circuit!

A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

Soldering Irons

Soldering irons are rated in watts, and can go up to 300 watts, although for working on PC boards, irons ranging from 15- to 40-watts are suitable. If a heavy-duty soldering iron is required, a 60-watt should be considered. However, if you use an iron with a higher wattage than 40 watts, you may damage the copper tracks on a PC board.

The tip is a very important part of the iron. A typical soldering iron tip is made up of four different materials, as shown in Figure 2. The core consists of copper, a good heat-conductor from the iron's heating element. Since copper is a soft material, it is plated with iron, which is then protected from oxidation by chrome plating in the non-soldering area. At the tip, where soldering is done, tin plating

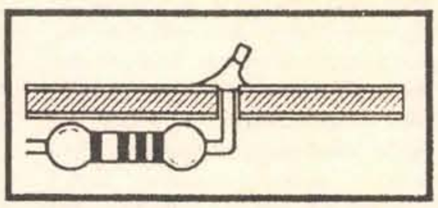

Figure 6 - A good solder connection.

allows easy cleaning.

A good, clean solder tip makes soldering much easier. The tip should be tinned by lightly coating it with solder to prevent it from oxidizing. The tip can become pitted with black spots from normal use. It is important to clean the tip by frequently wiping it with a wet sponge or rag.

Never use a file or abrasive material to clean the tip! This could damage the plating and ruin the tip. Also, do not remove excess solder from the tip after using, since the excess solder will prevent oxidation.

Solder Stations

Many solder stations are available in the marketplace, and some are pretty costly, well into the over-$100.00 range.

A solder station allows you to set the tip temperature of a soldering iron when less heat is needed. It allows the iron to "idle" at low heat for long life rather than having it at maximum heat when not being used, and can be raised quickly to a higher temperature by just turn-

✔ **HobbyTron.com**, 1185 South 1480 West, Orem, UT 84058
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FAX: (800) 470-1606
Website: www.hobbytron.com
E-mail: brad@littlefishcommerce.com

✔ **Information Unlimited**, P.O. Box 716,
Amherst, NH 03031
Orders/Catalogs Only: (800) 221-1705
Phone: (603) 673-4730, FAX: (603) 672-5406
See their ad on Page 32!

✔ **LNS Technologies**, Box 67243,
Scotts Valley, CA 95067
Phone: (831) 438-2028
FAX: (831) 438-0661
Website: www.techkits.com
E-mail: lnstech@ncal.verio.com
See their ad on Page 69!

✔ **Marlin P. Jones & Associates, Inc.**,
P.O. Box 12685, Lake Park, FL 33403
Phone: (800) 652-6733 Orders,
FAX: (800) 432-9937
Website: www.MPJA.com
See their ads on Pages 68-69!

✔ **Miller Engineering**, P.O. Box 382,
New Canaan, CT 06840-0282
Phone: (203) 595-0619
Website: www.microstru.com
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Phones: (888) 512-1024 U.S. toll-free,
(916) 624-8333 International
Website: www.parallaxinc.com
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✔ **Quality Kits**
Orderline: (888) 464-5487,
Free Catalog: (613) 544-6333
Website: www.qkits.com
See their ad on Page 68!

✔ **RadioShack Product Support**,
200 Taylor St., Suite 600, Fort Worth, TX 76102
Phone: (800) 843-7422. FAX: (817) 415-2303
Website: www.radioshack.com
E-mail: Many; see website product support page

✔ **Ramsey Electronics, Inc.**,
793 Canning Parkway, Victor, NY 14564
Phone: (800) 446-2295
or (716) 924-4560. FAX: (716) 924-4886
Website: www.ramseyelectronics.com
E-mail: OrderDesk@ramseyelectronics.com (Orders only)
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✔ **Ten-Tec, Inc.**, 1185 Dolly Parton Pkwy., Sevierville, TN 37862
Orders Only: (800) 833-7373
Free Catalogs: (865) 453-7172,
FAX: (865) 428-4483
Website: www.tentec.com
E-mail: sales@Tentec.com
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✔ **Transtronics**, 3209 W. 9th St., Lawrence, KS 66049
Phone: (785) 841-3089. FAX: (785) 841-0434
Website: www.xtronics.com/kits.htm
E-mail: kits@xtronics.com

✔ **USI Corp.**, P.O. Box N2052,
Melbourne, FL 32902
Phone: (321) 725-1000
See their ad on Page 20!

✔ **Velleman** — Dealers worldwide. Manufactures over 150 kits.
Website: www.velleman.be (Belgium)
E-mail (USA Sales & Support):
velleman.inc@velleman.be
E-mail (Information): info@velleman.be
See their ad on Page 42!

✔ **Weeder Technologies**
Phone: (850) 863-5723
Website: www.weedtech.com
See their ad on Page 85!

✔ **Worldwyde**, 33523 Eight Mile Road
#A3-261, Livonia, MI 48152
Phone: (800) 773-6698
Website: www.worldwyde.com
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Building Kits ...

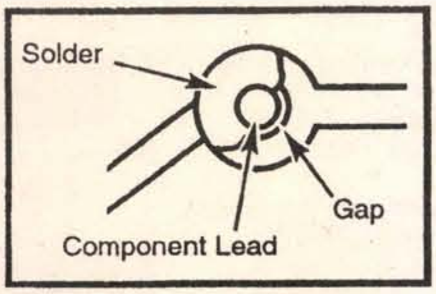

Figure 8 - Let the solder flow over the connection until it is covered.

ing a knob.

Solder stations also provide an on/off switch, left- or right-side iron holder, and a wet sponge for tip cleaning. Some come complete with a soldering iron, others allow you to plug in an iron of your choice.

For the average electronics student or hobbyist, the Elenco Model SL-5, as shown in Figure 1, is entirely adequate to provide control in a broad range of soldering situations. It is available both assembled or as a kit (SL-5K) for $29.95.

The SL-5 allows you to vary the tip temperature on any plug-in soldering iron up to 300 watts, has a lighted on/off switch, allows the iron holder to be placed on the left or right side, and includes a steel sponge tray and sponge. It even includes a ground fault safety circuit that uses a warning light if your station is connected to earth ground by having your hot and ground wires reversed.

Many optional accessories are available, as described at www.cs-sales.com, or call 1-800-292-7711 to request C&S Sales' free 64-page color catalog of hundreds of items from Elenco and other manufacturers.

Soldering to a PC Board

For single-sided PC boards, solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil, as shown in Figure 3. For double-sided PC boards, solder at all copper pads.

Apply a small amount of solder to the iron tip, allowing the heat to leave the iron and go onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron, as shown in Figure 4. Allow the heated component lead and the circuit foil to melt the solder.

Allow the solder to flow around the connection, as shown in Figure 5. Then remove the solder and the iron to let the connection cool. The solder should have flowed smoothly, and not lumped around the component lead. A good solder connection looks like Figure 6 after clipping off the excess component lead.

Poor Soldering

There are a number of causes for making poor soldering connections. For example, as shown in Figure 7, if you position the soldering iron on the component lead away from the PC board, there will be insufficient heat at the foil, and most of the heat will be transmitted to the component, possibly damaging it. The rosin core of the solder may create a solder bond with the component lead, but possibly not the foil.

In soldering to printed circuit pads, be sure the entire pad around the component lead is covered. Insufficient solder may leave a gap, as shown in Figure 8, which weakens the mechanical strength of the joint.

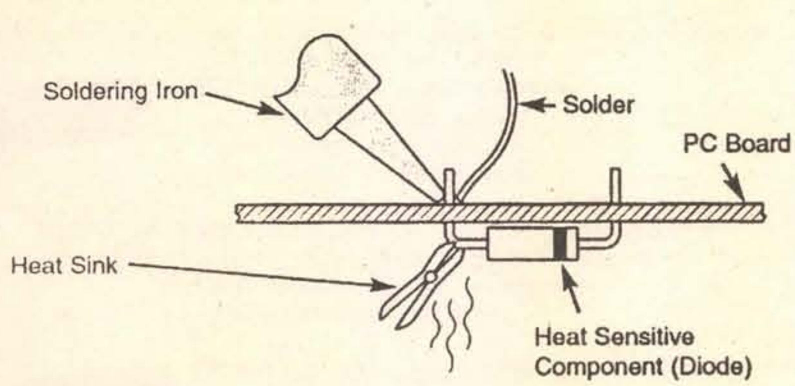

Figure 10 - It's a good idea to use a heatsink with some components.

On the other hand, as shown in Figure 9, too much solder can make connections you did not intend between adjacent foil areas or terminals, creating a short circuit. Sometimes a "solder bridge" can be corrected by dragging the tip of your soldering iron across the bridge to melt and brush the excess solder aside.

Heatsinking

Electronic components such as transistors, integrated circuits, and diodes, can be damaged by excessive heat during soldering. "Heatsinking" is a way of reducing the heat reaching the components while soldering. Dissipating the heat can be achieved by using long-nose pliers, an alligator clip, or a special heat-dissipating clip. The heatsink should be held on the component lead between the part and the solder joint, as shown in Figure 10.

Troubleshooting

Sometimes, careful as you might think you've been, when the kit is completed, it just does not work! There are a number of possible reasons for non-operation, but the most common reasons are improper parts placement or orientation, poor solder connections, or power problems.

Check the parts first. Do you have the right parts and values in the right places, according to the parts layout diagram, and are they "facing" properly? It is real easy to have an electrolytic capacitor, diode, transistor, integrated circuit, or other "polarity-sensitive" part inserted into the PC board or socket the wrong way.

Bad solder connections are notoriously guilty of causing problems in kit building. Check every connection with a magnifying glass. Any connection that is not smooth and shiny should be resoldered. Also note any parts that move when you check to see if they are solidly mounted. If they move at all, resolder their connections. And be sure there are no solder bridges where there shouldn't be. (Some component leads are next to each other, and have adjoining solder pads that are joined by the printed circuit. Bridges here are okay.)

If you are not acquainted with circuit tracing power using a voltmeter and schematic, ask a knowledgeable friend. Check that you have voltage where you should, starting at the voltage source, and proceeding to each component directly connected to power.

Of course, there is always the possibility of a defective part. While this does happen, it is actually one of the least likely causes of improper operation. Check the other things first.

Troubleshooting is more of an art than a science. It is useful to break circuits into sections, such as power, input, amplifier, output — examining each based on its function. There is probably no substitute for experience in troubleshooting complex projects.

Desoldering

If your troubleshooting discloses a misplaced or defective part, you must desolder that part to replace it, or perhaps just change its orientation.

There are various means for desoldering or unsoldering parts.

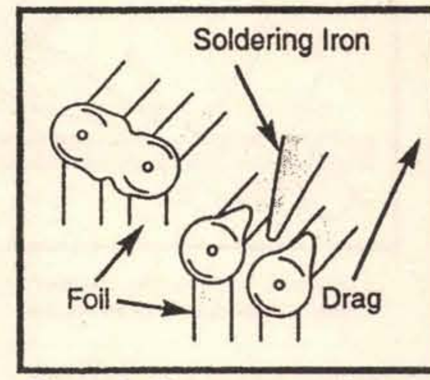

Figure 9 - You can sometimes clear a solder bridge by dragging the hot soldering iron tip across the bridge.

"Desoldering braid" acts as a wick to suck up solder from a heated joint. A "desoldering bulb" uses a vacuum to suck up solder from a heated joint, as does a "desoldering pump."

The least sophisticated method is purely manual. Two-lead parts are relatively easy to desolder. Just use a small tool to wedge under the part as you apply the soldering iron tip to one of the soldered lead connections.

Then unsolder the other lead while pulling on the part to release it. Be careful not to apply too much wedge pressure or you can pull the component right off the lead!

For three-lead items like transistors, use needle-nose pliers to remove the first two leads, then heat up the third lead connection and lift the transistor off the circuit board. For multiple-lead components, such as integrated circuits, use braid, vacuum bulb, or pump — or, better yet, use a socket!

How About Building From Scratch?

While this article briefly covers building projects from kits, a very complete book that covers building projects from scratch is *Electronic Project Design and Fabrication*, by Ronald A. Reis. The Fourth Edition is a large-format 525-page textbook that leaves nothing to the imagination, and includes many actual projects. This Prentice Hall book (ISBN 0-13-776055-8) is used by many technical schools and colleges. It is available from amazon.com for $80.00. Highly recommended! **NV**

Continued from page 42

PANAMAX SURGE protectors for AV, DBS, and satellite. 600+ units in stock. Several models. Computer Liquidations Ltd. 561-750-3318. www.liquidations.com

WANTED: MILITARY capacitors, resistors, transistors, diodes, ICs, semi's, etc. Please fax/E-Mail excess lists & RFQs 818-769-1002 fax 818-769-1084. electmatind@earthlink.net & http://www.militarycomponents.com

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WANTED: MILITARY capacitors, resistors, transistors, diodes, ICs, semi's, etc. Please fax/E-Mail excess lists & RFQs 818-769-1002 fax 818-769-1084. electmatind@earthlink.net & http://www.militarycomponents.com

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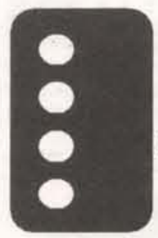

Easily copy your existing remote controls for garage doors, home security systems, car alarms, door locks, and remote starters.* Use the remote you haven't lost yet to create a spare, or combine your car alarm remote and your door security system remote on one keychain unit. Easy cloning instructions included. (Note: if your existing remote is code hopping, you will not be able to clone it successfully.)

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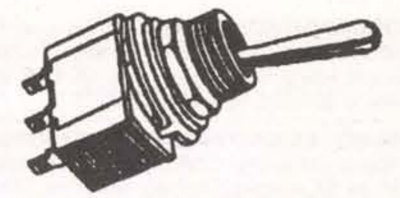

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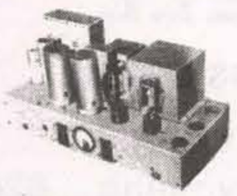

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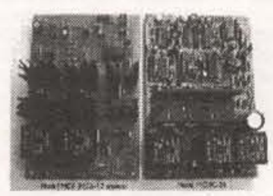

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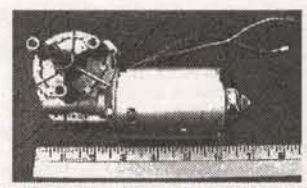

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Continued on page 85

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- BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH $550.00
- BOONTON 72BD 1 MHz Capacitance Meter, 3-1/2 digit display $650.00
- BOONTON 72C 1 MHz Capacitance Meter, 1-3000 pF full scale $800.00
- GR 1658 RLC Digibridge, 120 Hz/ 1 kHz $1,000.00
- GR 1659 RLC Digibridge, 120 Hz/ 1 kHz/ 10 kHz $1,100.00
- HP 4275A 5-1/2 digit LCR Meter, 10 kHz-10 MHz, HPIB $3,500.00

STANDARDS

- E.S.I. SR-1 Standard Resistor, various values $125.00
- E.S.I. SR1010 Resistance Transfer Standards, 1 Ohm-100 K/step $550.00
- GENERAL RADIO 1409-SERIES Standard Capacitors $150.00
- GR 1406 Standard Air Capacitors, GR900 connector, 0.1% acc. $275.00
- GR 1413 6-Decade Precision Capacitor, 0-1 uF, 1 pF resolution $1,500.00
- GR 1432-U 4-Decade Resistor, 0-111.10 Ohms, 0.01 Ohm resolution $100.00
- GR 1433-J 4-Decade Resistor, 0-11,110 Ohms, 1 Ohm resolution $150.00
- GR 1433-K 4-Decade Resistor, 0-1,110 Ohms, 0.1 Ohm resolution $150.00
- GR 1433-P 5-Decade Resistor, 0-1.1111 Megohm, 10 Ohm resolution $500.00

T.D.R.

- TEK 1503B-03,04 T.D.R., 0-50,000 ft., chart recorder & battery power $3,000.00
- TEK 1503-opt.04 Time Domain Reflectometer, 0-50,000 feet,chart recorder $1,400.00

POWER SUPPLIES

SINGLE OUTPUT

- HP 6024A 0-60 V / 0-10 A / 200 Watts max. CV/CC Power Supply $600.00
- HP 6033A Power Supply, 0-20 V / 0-30 A / 200 Watts max., HPIB $1,200.00
- HP 6110A 0-3000 V 0-6 mA CV/CL Power Supply $250.00
- HP 6201B 0-20 V 0-1.5 A CV/CC Power Supply $175.00
- HP 6203B 0-7.5 V 0-3 A CV/CC Power Supply $175.00
- HP 6207B 0-160 V 0-200 mA CV/CC Power Supply $200.00
- HP 6263B 0-20 V 0-10 A CV/CC Power Supply $375.00
- HP 6266B 0-40 V 0-5 A CV/CC Power Supply $375.00
- HP 6267B 0-40 V 0-10 A CV/CC Power Supply $550.00
- HP 6271B 0-60 V 0-3 A CV/CC Power Supply $375.00
- HP 6274B 0-60 V 0-15 A CV/CC Power Supply $650.00
- HP 6282A 0-10 V 0-10 A CV/CC Power Supply $200.00
- HP 6299A 0-100 V 0-750 mA CV/CC Power Supply $200.00
- HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply $125.00
- HP 6443B 0-120 V 0-2.5 A CV/CC Power Supply $450.00
- HP 6643A 0-35 V 0-6 A CV/CC Power Supply, HPIB $1,200.00
- HP 6652A 0-20 V 0-25 A 500 Watt Programmable Power Supply, HPIB $1,875.00
- KEPCO ATE 36-30M 0-36 V 0-30 A CV/CC Power Supply $900.00
- KEPCO ATE 36-8M 0-36 V 0-8 A CV/CC Power Supply $375.00
- LAMBDA LK-352-FM 0-36 V 0-15 A CV/CC Power Supply $600.00
- SORENSON DCR 150-3B 0-150 V 0-3 A CV/CC Power Supply $500.00
- SORENSON DCR 600-0.75B 0-600 V 0-750 mA CV/CC Power Supply $550.00
- SORENSON DCS 40-25 0-40 V 0-25 A CV/CC Power Supply $650.00
- SORENSON SRL 20-12 0-20 V 0-12 A CV/CC Power Supply $350.00
- SORENSON SRL 60-8 0-60 V 0-8 A CV/CC Power Supply $500.00

MULTIPLE OUTPUT

- HP 6205C Dual Power Supply, 0-40 V 300 mA & 0-20 V 600 mA, CV/CL $300.00
- HP 6228B Dual 0-50 V 0-1 A CV/CC Power Supply $375.00
- HP 6236B Triple Output Power Supply, +/- 0-20V 0.5A & 0-6V 2.5A $375.00
- HP 6253A Dual 0-20 V 0-3 A CV/CC Power Supply $375.00
- HP 6255A Dual 0-40 V 0-1.5 A CV/CC Power Supply $375.00
- KEPCO MPS-620M Triple Output Supply, dual 0-20V 1A tracking & 0-6V 5A $200.00
- TEK PS5010 Programmable Triple Power Supply, TM5000 series $450.00
- TEK PS503A Dual Power Supply, TM500 series $200.00

MISCELLANEOUS

- ACME PS2L-500 Programmable Load, 0-75 V / 0-75 A / 500 Watts max. $350.00
- BEHLMAN 25-C-D/OSCD-1 AC Power Source, 250 VA, 0-130 VAC, 45-2000 Hz $850.00
- HP 59501B HPIB Isolated DAC/Power Supply Programmer $175.00
- HP 6060A 300 Watt Programmable Load, 0-60 A / 3-60 V, HPIB $950.00
- HP 6827A Bipolar Power Supply / Amplifier, to 100 V, 500 mA $850.00
- KEPCO BOP 50-2M Bipolar Op Amp/Power Supply, to 50 V 2 A $400.00
- TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max. $200.00

TIME & FREQUENCY

UNIVERSAL COUNTERS

- HP 5314A 100 MHz/ 100 nS Universal Counter $175.00
- HP 5315A 100 MHz/100 nS Universal Counter $350.00
- HP 5315A-001 100 MHz / 100 nS Universal Counter, TCXO reference $400.00
- HP 5315A-002,003 100 MHz/100 nS Univ. Counter; batt. power & 1 GHz C-ch. $550.00
- HP 5315A-003 100 MHz/100 nS Univ. Counter, 1 GHz C-channel option $450.00
- HP 5316A 100 MHz/100 nS Universal Counter, HPIB $450.00
- HP 5370B 100 MHz/ 20 pS Universal Counter, 11 digits $1,200.00
- PHILIPS PM6672/411 120 MHz/100 nS Universal Counter, C-channel 70-1000 MHz $375.00
- TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series $200.00
- TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series $350.00
- TEK DC5010 350 MHz/ 3.125 nS Universal Counter, TM5000 series $750.00
- TEK DC503A 125 MHz/100 nS Universal Counter, TM500 series $275.00
- TEK DC509 135 MHz/ 10 nS Universal Counter, TM500 series $275.00

FREQUENCY COUNTERS

- FLUKE 7220A-010,131,351 1.3 GHz Counter; battery power, OCXO, and res. mult. $500.00
- HP 5342A 18 GHz Frequency Counter $900.00
- HP 5343A-001 26.5 GHz Frequency Counter, OCXO reference $3,000.00
- HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter $3,500.00
- HP 5364A Microwave Mixer / Detector, for modulation domain an. $2,000.00
- HP 5386A-004 3 GHz Frequency Counter, HPIB; OCXO reference option $1,000.00

STANDARDS

- HP 105B Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz, battery power $1,100.00

AUDIO & BASEBAND

SPECTRUM ANALYSIS

- HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms $1,200.00

DISTORTION ANALYSIS

- HP 8903A Audio Analyzer, 20 Hz-100 kHz $1,200.00

RMS VOLTMETERS

- FLUKE 8922A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz $450.00

OSCILLATORS

- HP 3336C-004,005 21 MHz Synthesizer/ Level Gen., OCXO & hi accuracy att. $1,400.00
- TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten.,TM500 ..... $200.00

MISCELLANEOUS

- HP 3575A Phase-Gain Meter, 1 Hz-13 MHz, single display $600.00
- HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display $850.00
- HP 467A Power Amplifier, X1/X2/X5/X10, DC-1 MHz, 10 W output $375.00
- KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave $350.00
- KROHN-HITE 3200 High Pass / Low Pass Filter, 20 Hz-2 MHz, 24 dB/octave $275.00
- KROHN-HITE 3202 Dual HP/LP/BP/BR Filter, 20 Hz-2 MHz, 24 dB/octave $450.00
- ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz $650.00
- WAVETEK 716 Brickwall Filter $1,500.00

RF & MICROWAVE

SPECTRUM ANALYZERS

- HP 11517A/18A/19A/20A Mixer Set, 12.4-40.0 GHz, for HP 8555A/8569A $500.00
- HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz $1,100.00
- HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz $1,100.00
- HP 11970Q WR22 Harmonic Mixer, 33-50 GHz $1,400.00
- HP 11971A WR28 Harmonic Mixer, for HP 8569B $800.00
- HP 11971K WR42 Harmonic Mixer, for HP 8569B $800.00
- HP 8449B Preamplifier, 1.0-26.5 GHz $4,500.00
- HP 8559A/853A-001 Spectrum An., 0.01-21 GHz, 1 kHz res.,w/rackmount frame $3,500.00
- HP 85640A Tracking Generator, 300 kHz-2.9 GHz, for HP 8560 series $5,000.00
- HP 8565A-100 Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min. res. bw. $3,000.00
- HP 8568B Spectrum Analyzer, 100 Hz-1.5 GHz, 10 Hz min. res. $8,500.00
- HP 8569B Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min.res.bw. $5,500.00
- TEK 492-opt.02 Spectrum Analyzer, 50 kHz-18 GHz, 1 kHz res. $4,250.00
- TEK WM782V WR15 Harmonic Mixer, 50-75 GHz $1,500.00

NETWORK ANALYZERS

- HP 11650A Network Analyzer Accessory Kit, APC7 ..... $600.00
- HP 11665B Modulator, 0.15-18 GHz, for HP 8755/6/7 ..... $250.00
- HP 4815A Vector Impedance Meter, 0.5-108 MHz, 1 Ohm-100 kilohm $1,200.00
- HP 8502A Transmission/ Reflection Test Unit, 0.5-1300 MHz $675.00
- HP 85054A Type N Calibration Kit, for HP 8510 series $1,800.00

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'555' Monostable Circuits

by Ray Marston

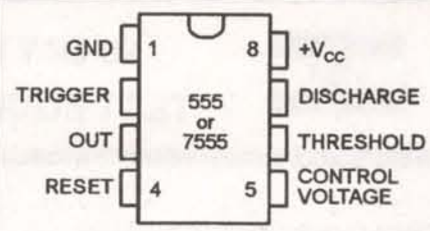


Figure 1. **Outline and pin notations of the eight-pin DIL versions of the 555 (or 7555) timer IC.**

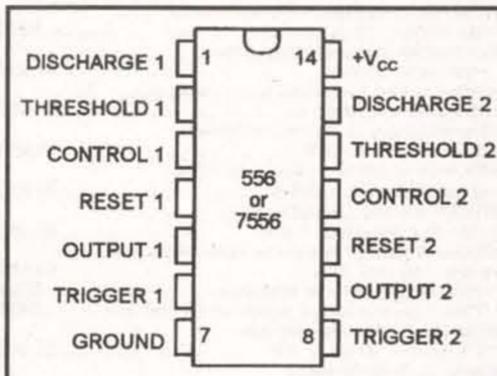


Figure 2. **Outline and pin notations of the 14-pin DIL version of the 556 (or 7556) 'dual timer' IC.**

In this '555 timer IC' application article, Ray Marston shows ways of using the IC in basic 'timer' or 'one-shot' (monostable) circuits.

Timer ICs are designed to generate accurate and st able C-R – defined timing periods, for use in monostable 'one-shot' pulse generator and free-running astable squarewave generator applications. The best known timer ICs are the '555' family of devices, which are available in both single (555) and dual (556) bipolar packages and also in CMOS forms (7555 and 7556); they use a mixture of linear and digital IC technology. This article explains 555 basics and shows ways of using the IC in monostable applications.

555 BASICS

The 555 is a versatile timer IC that generates stable timing periods from a few microseconds to hundreds of seconds via a simple C-R network, and gives good output waveforms with typical rise and fall times of 100ns. When used in the monostable mode, its output can be pulse-width modulated (PWM) and, in the astable mode, it can be subjected to frequency-sweep control, to frequency modulation (FM), or to pulse-position modulation (PPM). *Figures 1* to *3* give basic outline and performance details of the bipolar 555 and 556 ICs and their CMOS counterparts, the 7555 and 7556.

Figure 4 shows (within the double lines) the functional diagram of the bipolar 555 IC; the supply-driven 3 x 5k0 potential divider generates a 1/3 V_{cc} reference voltage on the non-inverting input of the lower voltage comparator and a 2/3 V_{cc} reference on the inverting input of the upper comparator. The comparator outputs control the R-S flip-flop which, in turn, controls the output stage and slave transistor Q1; the flip-flop state can also be controlled via pin 4. The diagram also shows the connections for using the 555 as a basic monostable multivibrator or timer, and the following explanation assumes that the IC is connected in this configuration.

When the *Figure 4* timer circuit is in its quiescent state, pin 2 is held high via R4, Q1 is saturated and forms a short across timing capacitor CT, and pin 3 (output) is driven low. The monostable timer action is initiated by feeding a neg-

Parameter	Bipolar 555	CMOS 7555
Power supply range	4.5V to 16V	2V to 18V
Supply current at V_{cc} = 15V	10mA	0.1mA
Output current, max.	200mA	100mA
Power dissipation, max.	600mW	200mW
Peak supply current transient	400mA	10mA
Timing accuracy, drift with V_{cc}	0.1%/V	1%/V
Input current, trigger	100nA	0.01nA
Input current, threshold	500nA	0.01nA
Input current, reset	100µA	0.02nA
Output rise and fall times	100ns	40ns
Minimum trigger-pulse width	20ns	90ns
Threshold voltage	$1/2V_{cc}$	$2/3V_{cc}$
Trigger voltage	$1/3V_{cc}$	$1/3V_{cc}$
Reset voltage	0.7V	0.7V

Figure 3. **Typical bipolar 555 and CMOS 7555 parameter values.**

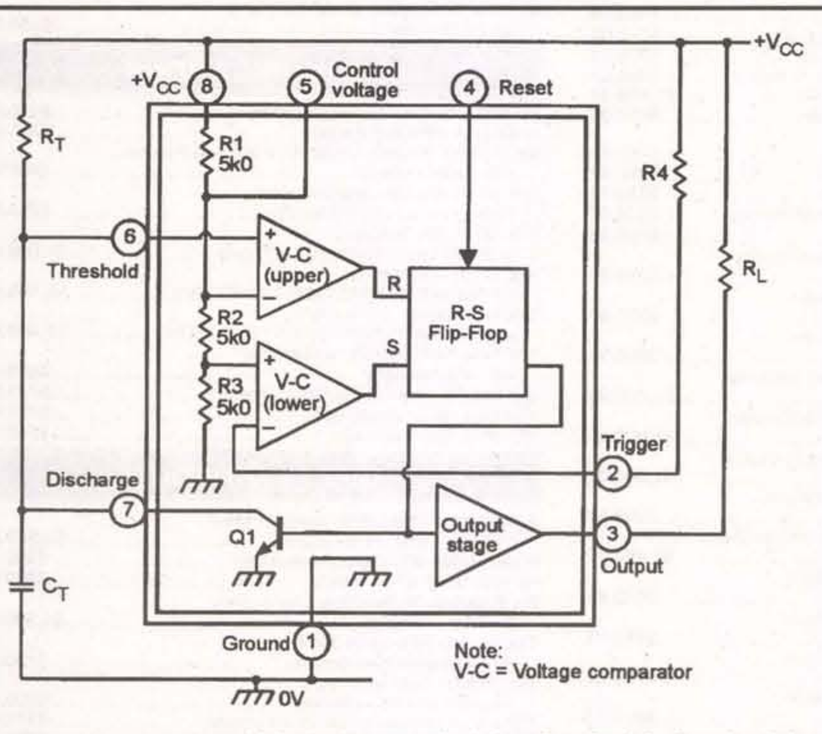


Figure 4. **Functional block diagram (within the double lines) of the 555 timer IC, with external connections for use as a 'timer.'**

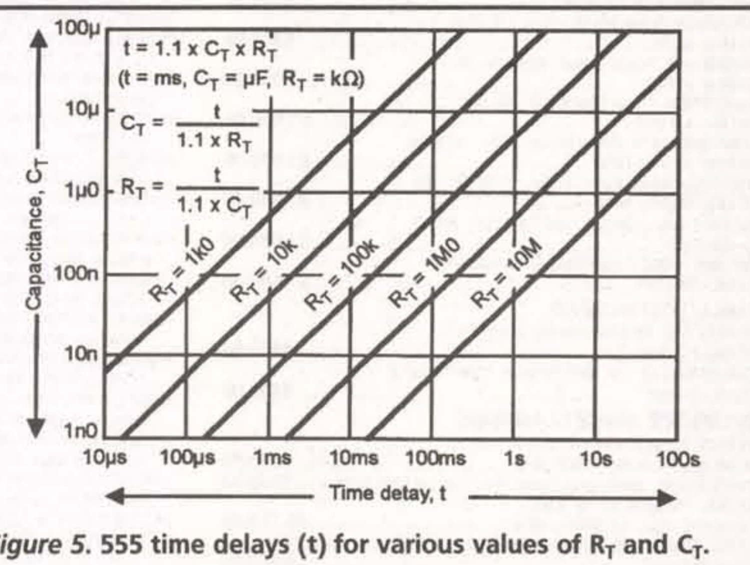


Figure 5. **555 time delays (t) for various values of R_T and C_T.**

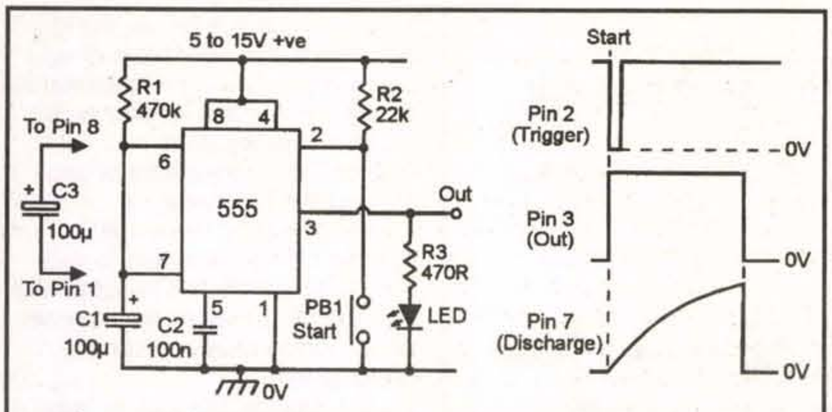


***Figure 6*. Circuit and waveforms of a simple 50s timer, with optional RFI suppression via C3.**

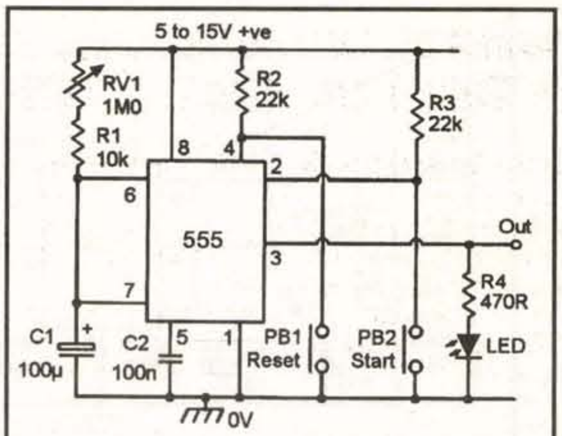


***Figure 7*. 1.1s to 120s timer with RESET facility.**

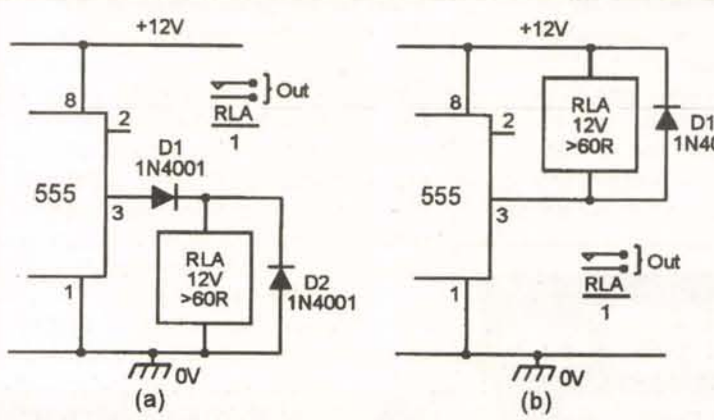


***Figure 8*. Alternative ways of driving a relay from the output of a 555.**

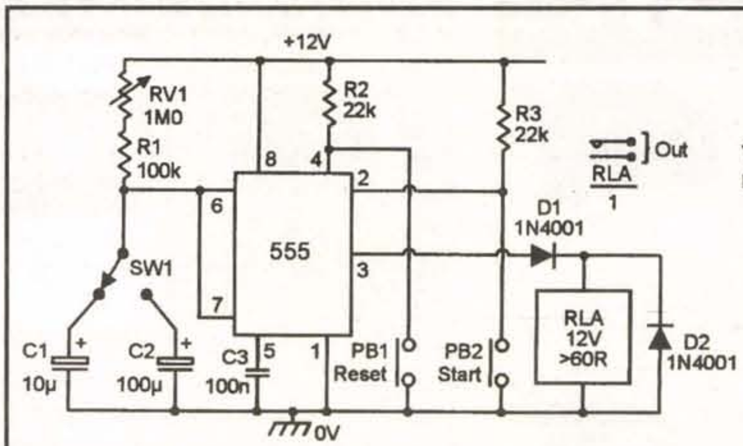


***Figure 9*. Simple two-range, 1.1s to 120s, relay-output timer.**

ative-going trigger pulse to pin 2, and as this pulse falls below the internal 1/3 V_{cc} reference, the output of the lower comparator changes state and switches the R-S flip-flop over, turning Q1 off and driving the pin 3 output high. As Q1 turns off, it removes the short from C_T, which starts to charge exponentially via R_T until eventually its voltage rises to 2/3 V_{cc}, at which point the upper comparator changes state and switches the R-S flip-flop over again, turning Q1 on and rapidly discharging C_T and simultaneously switching output pin 3 low again, thus completing the operating sequence.

Note that, once triggered, this circuit cannot respond to additional triggering until the timing sequence is complete, but the sequence can be aborted at any time by feeding a negative-going pulse to RESET pin 4. The timing period, in which the pin 3 output is high, is given as

$$t = 1.1 \times C_T \times R_T,$$

where t is in ms (milliseconds), C_T is in µF, and R_T is in kilohms.

Figure 5 shows how delays of 10µs to 100s can be obtained via C_T and R_T values in the range 1nF (= 1000pF) to 100µF and 1k0 to 10M; C_T must be a low leakage component. The timing periods can also be varied by applying a variable resistance or voltage between ground and the pin 5 CONTROL VOLTAGE terminal of the IC; this facility enables the periods to be externally modulated or compensated.

555 OR 7555?

All practical circuits shown in this article are designed around the standard bipolar 555 IC but, in most cases, will work equally well (or better) with a 7555 or similar CMOS version of the timer IC. Here are a few notes on the relative merits of the inexpensive bipolar 555 IC and its more expensive CMOS cousin, the 7555. The 555 is very popular, but cannot use supplies below 4.5V and typically draws 10mA of quiescent current when operating from 15V. Worst of all, it draws a brief (a fraction of a microsecond) but massive 400mA spike of supply current as its output transitions from one state to the other, and this generates an RF noise burst that can play havoc with nearby digital circuits. In critical 555 applications, this RF burst can be suppressed by wiring an electrolytic capacitor (10µF to 100µF) directly between supply pins 8 and 1.

The 7555 CMOS device suffers from none of these snags; it can use supplies in the range of 2V to 18V, draws only 100µA quiescent from a 15V supply, and draws a peak spike current of only 10mA when its output transitions from one state to the other, thus generating negligible switching RFI.

Figure 3 shows a rationalized comparative summary of the 7555 and 555 characteristics. Note, on the debit side, that the 7555 performance is inferior in terms of drift-with-voltage accuracy, in some pulse-trigger characteristics, and in its output current drive and power dissipation capabilities (the 7555 output can typically sink a maximum of 100mA but can source only 10mA).

Note that some 'low-power 555-type' ICs (such as the TS555CN) use CMOS rather than bipolar technology; these ICs draw a very low supply current. Finally, remember that dual versions of both the 555 and 7555 are available in 14-pin DIL IC packages; the dual 555 is known as the 556, and the dual 7555 is known as the 7556.

PRACTICAL 555 TIMER CIRCUITS

Figure 6 shows a practical fixed-period (about 50s) manually-triggered 555 timer and its circuit waveforms. It is similar to *Figure 4* except that the timing action is initiated by briefly closing START switch PB1, that pin 5 is decoupled via C2, and that the output state is visible via an LED. The fixed-period output pulse (set via R1-C1) is available at pin 3, and a high-impedance exponential sawtooth is available at pin 7. The circuit has optional RF suppression provided via C3.

Figure 7 shows how the timing period of the basic *Figure 6* circuit can be made variable from 1.1s to 120s by replacing R1 with a series-wired 10k fixed and 1M0 variable resistor, and how a RESET facility can be added to the circuit, enabling the timing period to be aborted at any moment.

The 555 can directly drive non-inductive loads (via pin 3) at currents up to 200mA, but if relay coils or other inductive loads are used, the connections of *Figure 8* must be used; the diodes protect the IC against inductive-switching damage. In *Figure 8(a),* the relay is normally off, but goes on while pin 3 is high during the timing period. In *Figure 8(b),* the relay is normally on, but turns off during the timing period.

Figure 9 shows a relay-output timer that spans 1.1s to 120s in two decade ranges. This is a useful general-purpose circuit, but consumes current even when the timer is in the 'off' mode, and its two RV1 scales must both be calibrated, since timing capacitors C1 and C2 are wide-tolerance electrolytic types. *Figure 10* shows how these two defects can be overcome.

Power is fed to the *Figure 10* timer via PB1 or relay contacts RLA/1, which are normally both open. The timing cycle is started by briefly closing PB1, thus connecting power to the circuit. Initially, C3 is fully discharged and thus feeds a start pulse to the 555's pin 2 via R4, thus starting the timing cycle and driving relay RLA on and closing RLA/1's contacts, which then maintain the circuit's power connection even when PB1 is released.

At the end of the timing cycle, the relay turns off again and contacts RLA/1 re-open, thus removing the circuit power again. The circuit's timing is controlled mainly by R1-RV1 and by C1 or C2, but is also influenced by the settings of RV2 and RV3, which connect to pin 5 of the IC and enable the timing to be 'trimmed' so that the two timing ranges can use a single calibrated scale, even though wide-tolerance timing capacitors are used.

To initially set up the *Figure 10* circuit, first set RV1 to maximum value, set range switch SW1 to position '1,' activate START button PB1, and trim RV2 to give a timing period of precisely 10s. Next, set SW1 to position '2,' activate PB1, and trim RV3 to give a timing period of 100s. Adjustments are then com-

plete, and the timing scale can be calibrated over the full '10s' range.

Figure 11 shows an automatic delayed-turn-off headlight control system for use in automobiles; it holds the headlights on for a pre-set period after the car is parked, thus illuminating a pathway, etc.; it does not interfere with normal headlight operation under actual driving conditions. It works as follows.

When the ignition switch is on, RLA is driven on via D3, and contacts RLA/1 are closed, connecting the 12V supply to both the timer circuit and the headlight switch. The headlights thus operate in the normal way under this condition, but C2 is fully discharged. When the ignition is first switched off, the relay tries to open, but at that instant, a negative trigger pulse is fed to the timer via C2 and initiates a 50s timing cycle that feeds current to the relay coil via D2, thus maintaining RLA/1's connection to the headlight switch for 50s after the ignition is turned off. At the end of this period, RLA turns off and contacts RLA/1 open, breaking the supply connection to the timer circuit and the headlight switch, and the operation is complete.

The above mode of circuit operation is compatible with most modern vehicles, in which the headlight switch is fed via the ignition switch. On older types of vehicles – where headlight operation is independent of the ignition switch – a manually-triggered delayed-turn-off headlight or spotlight control facility can be obtained by using the circuit in *Figure 12*. The action here is such that, if the vehicle has its lights off, they can be turned on for a pre-set 50s period by briefly pressing a START switch.

To complete this look at 'timer' applications of the 555 IC, *Figure 13* shows a 'smart' timer that automatically turns a porch light on for 50s when the presence of a visitor is detected, but does so only under dark conditions. The visitor's presence is detected via SW1 (a micro-switch activated by a porch gate, or a pressure-pad switch activated by body weight), and the dark condition is detected by a cadmium-sulphide light-sensitive resistor (LDR).

Circuit operation relies on the fact that timer triggering can only occur if the IC's pin 2 trigger pulse falls below the '1/3 V_{CC}' value, and in *Figure 13,* the pulse is generated

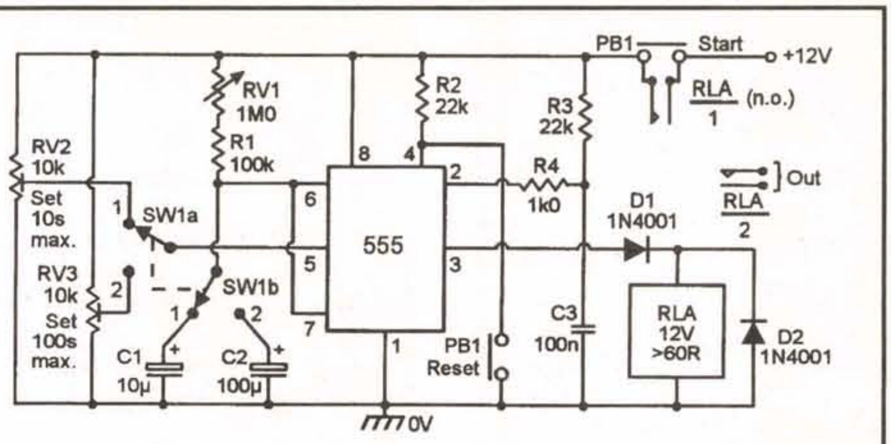


***Figure 10.* Precision (compensated) two-range (0.9s-10s, 9s-100s) timer.**

by closing SW1, but the pulse magnitude is controlled by the LDR-RV1 potential divider and depends on light level. Under bright conditions, the LDR-RV1 junction voltage is high, so effective trigger pulses cannot be generated, but under dark conditions, the LDR-RV1 junction voltage is low, and effective trigger pulses are generated each time SW1 is closed. The LDR needs a resistance in the range 1k0 to 47k at the required minimum 'dark' turn-on state, and RV1 sets the minimum 'dark' level at which the circuit will trigger.

PULSE GENERATOR CIRCUITS

The 555 can be used as a pulse generator by feeding suitable trigger signals to pin 2; it can generate good pulses with periods from 5μS upwards; its maximum useful pulse repetition frequency is about 100kHz. Pin 2 trigger signals must be negative-going pulses with amplitudes that switch from an OFF value above 2/3 V_{CC} to an ON value below 1/3 V_{CC} (triggering actually occurs as pin 2 drops

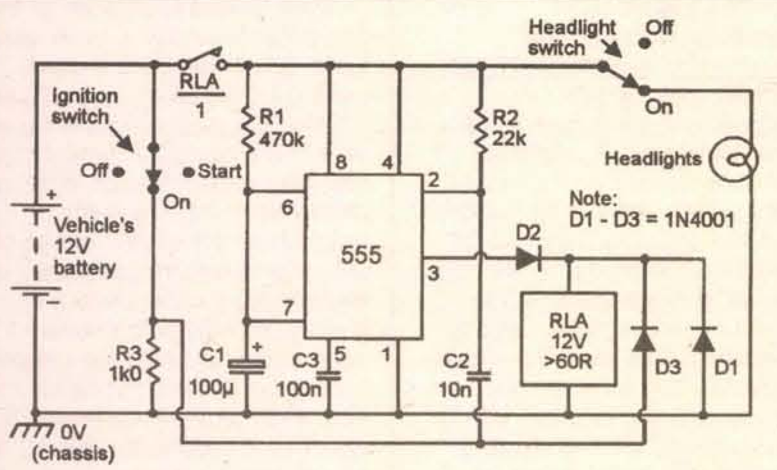


Figure 11. **Automatic delayed-turn-off headlight control system for cars.**

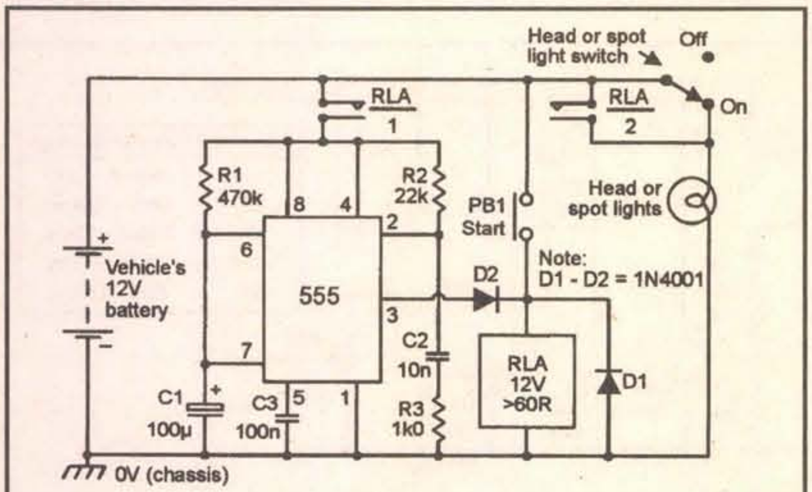


Figure 12. **Manually-triggered delayed-turn-off light control system for cars.**

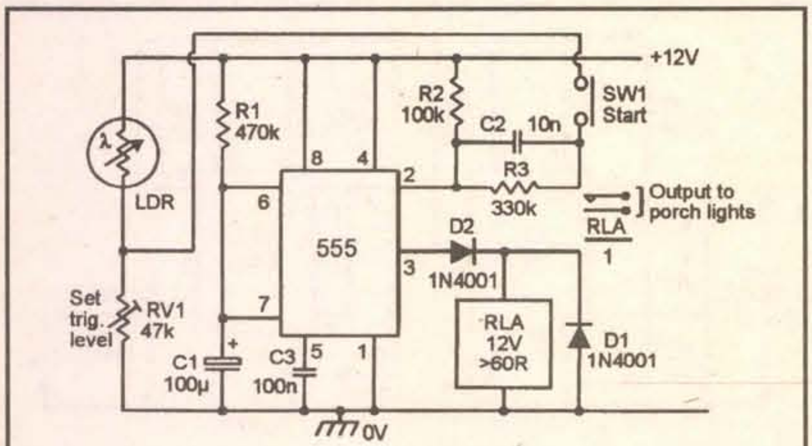


Figure 13. **Automatic porch light turns on for a pre-set period only when triggered at night.**

below 1/3 V_{CC}), and their width must be greater than 100nS, but less than that of the desired output pulse.

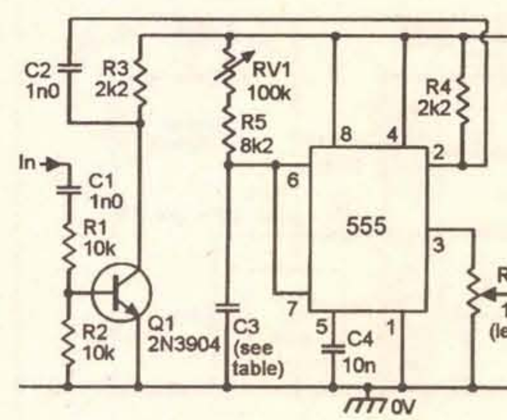
Figure 14 shows a practical pulse generator that is triggered via rectangular input signals and can be used as an 'add-on' facility with an existing waveform generator. Q1 converts the input signal into one that switches fully between the supply-rail values, and this is differentiated into an appropriate trigger-pulse form via short time-constant network C2-R4 and fed to pin 2 of the 555. Variable-amplitude output pulses are available via RV2, and their widths are variable over a decade range via RV1, and can be switched in decade ranges by using the C3 values shown in the table. The total pulse width range spans 9µS to 1.2s. C4 enhances circuit stability.

Figures 13-15 show the circuit modified so that it can be directly driven by any type of input, including a sinewave; IC1 is wired as a Schmitt trigger and converts all inputs into a rectangular form that drives the IC2 monostable in the same way as described above. This circuit can be used as an add-on pulse generator in conjunction with any free-running generator that gives peak-to-peak outputs greater than 1/2 V_{CC}.

To complete this look at 555 pulse generator circuits, *Figure 13-16* shows three 555 ICs used to make an add-on delayed-pulse generator in which IC1 is used as a Schmitt trigger, IC2 is a monostable that is used to control the pulse's delay width, and IC3 is used as the final pulse generator. The final output pulse appears some delayed time (set via IC2) after the application of the initial input trigger signal.

ANALOG FREQUENCY METERS

One special application of the 555 pulse generator is as an analog meter driver that gives a direct reading of frequency, as in *Figure 17*. The IC's pulse output is fed to 1mA FSD moving-coil meter M1 via multiplier resistor R5 and offset-cancelling diode D1. The meter responds to the MEAN voltage of the pulse waveform (integrated over several trigger cycles), which is directly (linearly) proportional to input frequency. With the component values shown, this circuit reads 1kHz FSD (set via RV1); other FSD values (from 100Hz to 100kHz) can be obtained by using alternative C3 values. The meter can be made to read frequencies up to 10s of MHz by feeding the input signals to the



C3 value	Pulse width range
10µF	90mS - 1.2s
1µF	9mS - 120ms
100nF	900µS - 12ms
10nF	90µS - 1.2ms
1nF	9µS - 120µs

Figure 14. **Simple add-on pulse generator is triggered by rectangular input signals.**

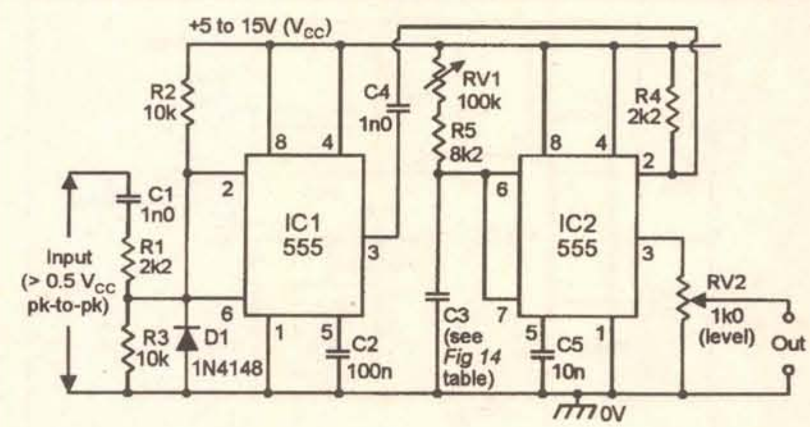


Figure 15. **Improved add-on pulse generator is triggered by any input waveform.**

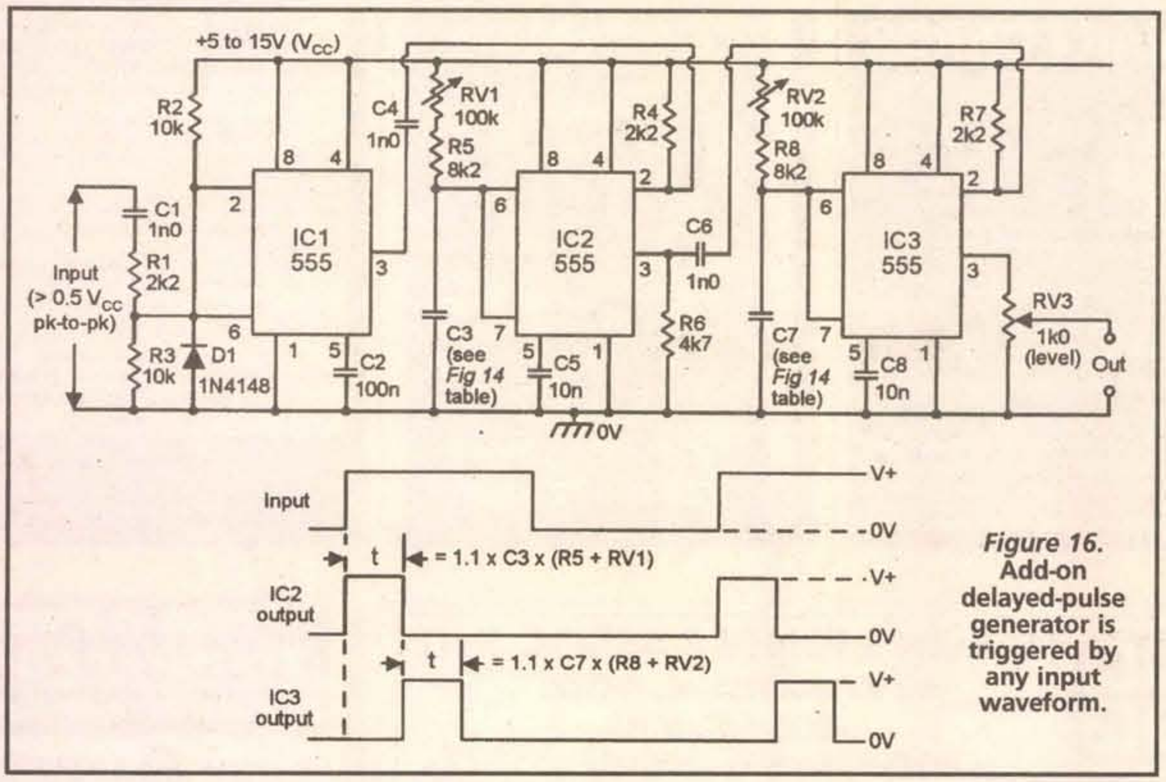


***Figure 16.* Add-on delayed-pulse generator is triggered by any input waveform.**

555 via a digital divider.

Figure 18 shows the circuit modified as an analog tachometer (RPM meter) for use in cars or motorcycles. It is powered by a regulated 8V2 supply (derived via the ignition switch) and is triggered by the vehicle's contact breaker (CB) points via the R2-C2-ZD2 waveform-conditioning network. The circuit action is such that current is applied to the 50µA FSD meter via R5-RV1 and the IC supply line when the IC output is high, but is reduced to near-zero (via D1) when the output is low.

The *Figure 17* and *18* circuits use regulated supply lines, to ensure constant pulse amplitude and thus a stable reading accuracy in the meter, which is used as a voltage indicator via the use of suitable 'multiplier' resistors. *Figure 19* shows (in basic form) an alternative way of making an analog frequency meter, by feeding the 555's output to the meter via JFET transistor Q1, which is wired (via RV1) as a constant-current generator, and thus feeds a fixed-amplitude pulse into the meter, irrespective of variations in supply line voltage, etc.

MISSING-PULSE DETECTOR

Finally, *Figure 20* shows an event-failure alarm or 'missing-pulse' detector, which operates a relay or LED if a normally recurrent event fails to take place. The 555 is wired as a normal pulse generator, but Q1 is wired across timing capacitor C1 and is driven via trigger pin 2, which is fed with a series of brief pulse- or switch-derived clocking signals from the monitored event. The R3-C1 values are chosen so that the 555's monostable period is slightly longer than the repetition period of the clock input signals.

Thus, each time a clock pulse arrives, it rapidly discharges C1 via Q1 and simultaneously initiates a timing cycle that drives pin 3 high, but before the cycle can end, naturally a new clock pulse arrives and repeats this process. Consequently, pin 3 remains high so long as clocking input signals arrive within the prescribed period limit, but goes low and turns on the relay and LED if a clock pulse is missing or its period exceeds the pre-set limit. The circuit thus acts as an event-failure alarm or missing-pulse detector; with the component values shown, its natural monostable period is about 30s, but is variable via R3-C1 to suit individual needs.

Note in the *Figure 20* circuit that the pin 2 trigger signals must be negative-going pulses with amplitudes that switch from an OFF value above 2/3 V_{CC} (but not greater than Vcc) to an ON value below 1/3 V_{CC}. **NV**

Next month, Ray covers '555' Astable Circuits. He'll show you ways of using the IC in a variety of astable waveform generator circuits.

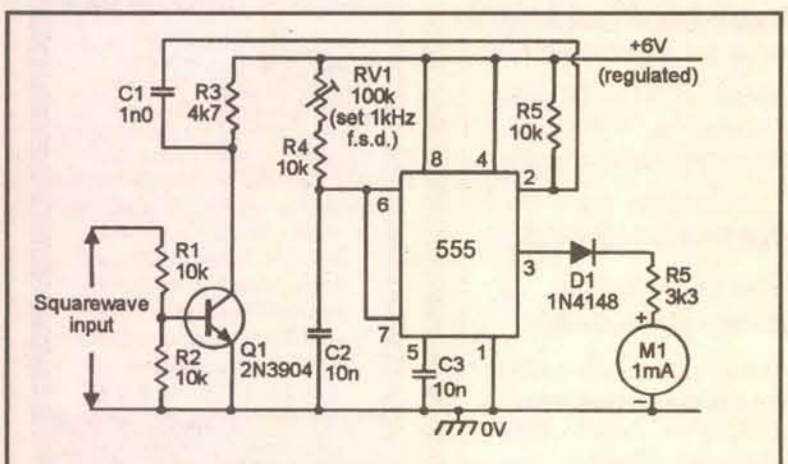


***Figure 17.* Simple 1kHz linear-scale analog frequency meter.**

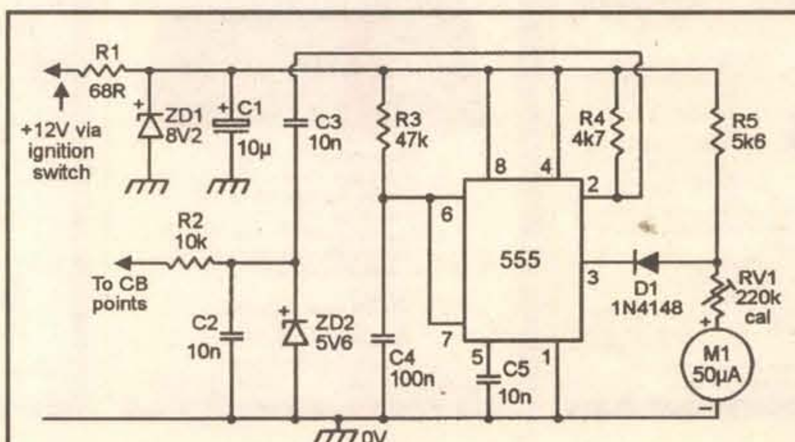


***Figure 18.* Car/motorcycle tachometer circuit.**

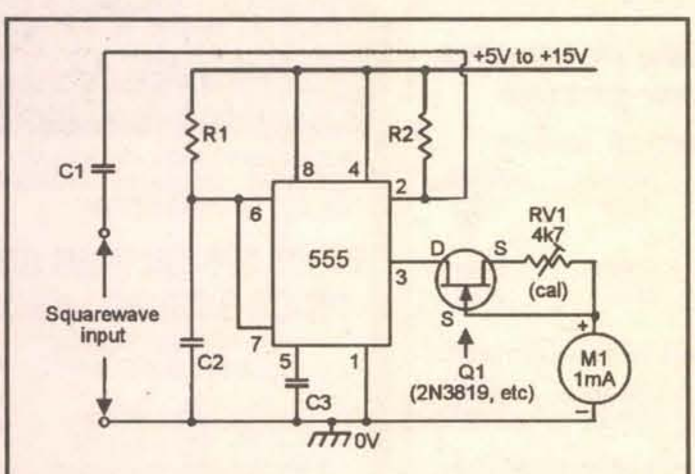


***Figure 19.* Alternative version of the analog frequency meter.**

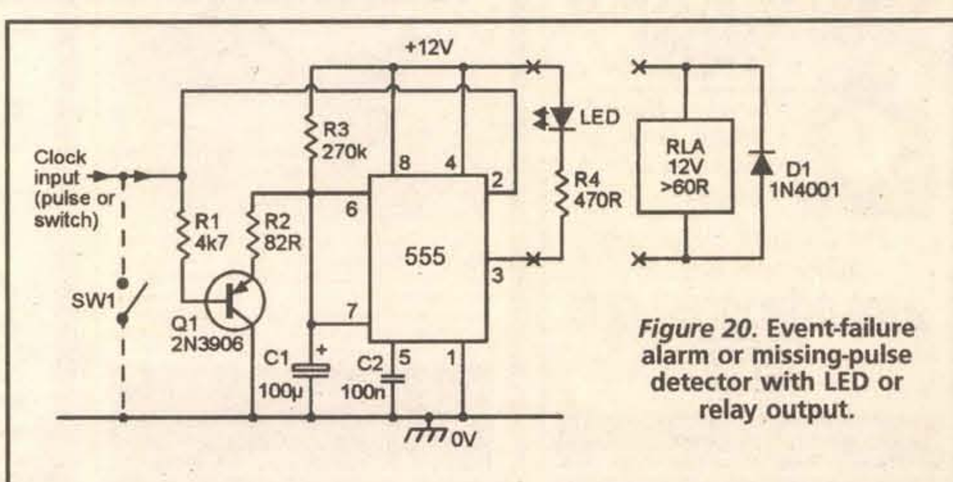


***Figure 20.* Event-failure alarm or missing-pulse detector with LED or relay output.**

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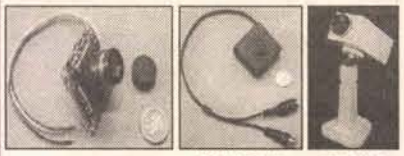

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Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

QUESTIONS

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

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Just click the bulletin board link at www.nutsvolts.com and check it out.

We expect to see all of you there soon. It's just getting started, but heck, it's free and a lot of fun too. Also it's educational and your boss will let you contribute during worktime. (Well, maybe on your lunch.) See, there's no good reason not to check it out.

I need to find or build a 7.8 DC power supply at 1 amp. Can anyone help me.

11001 — **Emmett Toomey**
Rio WV

I need a schematic diagram and parts list for a power supply from a McIntosh II si computer, model APS-06. Made by Sony or Apple? Parts #699-0567, serial #076959.

I received no help from Sams, Sony, or Apple.

11002 — **Edward Kubecka**
Valley Spring, TX

Does someone know of a good source of single line array photo detectors (say three to four inches long by one pixel?) linear encoder?

11003 — **Rich Ledvora**
via Internet

How can the 120V AC section of a motion detecting security light be eliminated, and the remaining 24V circuit be wired to run off a wall transformer?

Reference to any previous articles on motion detectors would be much appreciated.

11004 — **Ken Schultis**
via Internet

Hurricane Floyd drowned our spare repeater and destroyed our tech manual. We need a tech manual for an Advanced Computer Control's model RC-85 repeater controller.

11005 — **Curt Powell**
Rocky Mount, NC

My group has been tasked with repairing the following units. We do not have any documentation and I am told that it is not available to us from the manufacturer. This equipment is Motorola cell-site units. I believe it is early cell technology.

We need any and all documentation for these units.

System: HDII, NAMPS products:

SLF2750A PCB, VOICE XCVR (HSII) S/N 667PS01WH or E0086356; SGLF1030A PCB, VOICE XCVR (HSII) S/N 549VL29MJ or E0086321; STF2240A PCB, POWER AMP (HDII) S/N 667PS11N9 or E0086288.

Below is a complete list of part numbers we are targeting. We need any and all documentation for these units.

System: HDII, NAMPS products. Part numbers:

SLF2750A
SGLF1030A
STF2440A
STF2450A
SLF1008A
STF2240A
SGLF1031A

We will pay for any documents we can get.

11006 — **Judd Hodgson**
Verizon Logistics
Ontario, CA

Can someone please tell me the correct name for the metal strips which have a recorded message or music on them? They are found in the spine of greeting cards and play when the card is opened. I also need a source.

11007 — **G. Evans**
via Internet

I need a schematic for a timer circuit. The total time is 20 seconds with a warning when five seconds are left.

I have tried using two 555 ICs. The first one would count down 15 seconds and then trigger a buzzer for a chirp and another 555 would count down five seconds which would then trigger the buzzer on for up to two seconds. I can't seem to get it just right. Can someone help me?

11008 — **Sidney Simon**
Lafayette, LA

I haven't found any BCD up/down/presetable counter chips that are compact with multiple stages that drive seven-segment displays (something cascadable at least out to 10 digits).

I know this would be older technology. Everything available looks suited for 3-1/2 or 4-1/2 digits (mostly non-cascadable). Also, I didn't want to do a PC board with adding, say, 10 to 20 74LS193s along with a BCD to seven segment decoders and such.

If someone knows of a beast other than making a micro do it, I'd appreciate the info.

11009 — **Rich Ledvora**
via Internet

Does someone know of any vendor selling cost-competitive absolute shaft encoders?

And/or has anyone seen any available incremental or absolute encoders using magnetic sensing that wipers are not used in?

110010 — **Rich Ledvora**
via Internet

Due to considerable agitation about our electric power reliability here in Southern California, I now have an engine-driven generator for emergencies.

Unfortunately, I have found some references to the unsuitability of the brute force type generator for solid-state devices. I put a scope on the output at load and it seemed to produce 60-cycle power, but with tiny "notches" along the trace lines. I checked the large number of solid-state devices I have in my home and it surprised me. Irrigation controller, microwave oven, refrigerator, TV, clocks. Are these concerns valid?

110011 — **Charles Forman**
via Internet

Where can I get a cable or pinout diagram for my Moniterm VK2400? It must be a nine-pin, two-row to 15-pin, three-row cable.

110012 — **Casey King**
Columbus, OH

The automatic door lock circuit for my Caddy went bad. I tried using a couple of relays and two 4700uF caps, but could not get it to work quite right.

There are two switches: one in park and one in drive that provide a constant 12 volts.

The main power is provided at

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:

1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

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- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

ANSWERS TO #10004 - OCT. 2000

Does anyone have ideas on how to make a car error code reader, that could interface with the serial port on a laptop? I have a 1996 Chevy Monte Carlo.

#1 I would spend the $30.00 and buy a commercial error code reader.

Yes, they are simple devices and you can cobble one together for a few bucks, and you can make it more general so it works for several different manufacturers.

You can trick up the user interface on the laptop so it deciphers "Error 39" into something more meaningful.

But consider how much time you will spend doing that work, and after all that work you will still need to fix your car.

Also, the test ports have bizzare connectors that you must match or kludge.

Look at it this way. If you spend $30.00 to buy the right connector, you get the rest of the analyzer for free. If that does not convince you, then consider the car repair side. You don't need one of these analyzers unless your check engine light comes on. If it's on, then buying a $30.00 analyzer might save you $500.00 in auto repairs.

If you spend the $30.00 to find out what is wrong and fix it yourself, you are ahead of the game. If you cannot fix it yourself, $30.00 is a small tax on $500.00, and you still have the analyzer for the next time around.

The risks are not pretty, either. If you do it wrong, you may ruin either the car's test port or your laptop's serial or parallel port.

Serial ports are more robust than parallel ports, so there is some solace there.

Although I have tried to be careful, I have blown the parallel port on one motherboard and may have blown the LAN wakeup port on another. Ruining the serial port on a $1,500.00 laptop could wreck your day.

I have no idea how robust the test port on your car is, and I do not think it is worth finding out unless you go into the business of making car error code readers.

Gerald Roylance
Mountain View, CA

#2 In the current issue (#123, Oct. 2000) of *Circuit Cellar*, Dan Harrison has published a detailed description of how he designed and built his onboard scan diagnostic tool, called the OBDScan.

His MC68HC705-based device brings the diagnostic info out to a RS-232 serial port. He has made the OBDScan available in kit form, or assembled.

Check out his web site at www.ghg.net/dharrison.

The year 1996 was evidently the break-over year. For automobiles earlier than that the specs you need are hard to find unless you have a friend at the dealer's shop.

Some standards were invoked in 1996, so possibly Dan's article will tell you just what you need to know. In any case, it definitely looks like the place to start.

Circuit Cellar's web site is at www.circuitcellar.com or call their office at 860-875-2199 or fax to 860-871-0411.

Jack Dennon
Warrenton, OR

the ignition circuit. It looks like there are a couple of one-shot ICs in there.

Also, there is a relock feature that relocks the doors when the passenger opens their door through the ground pin in the door column. Any help would be appreciated.

110013 Frederick W. Rembetski
via Internet

I am working on a low-budget robotic system, and would like to use a buried wire or cable to guide the robot. I need to know a cheap way of building the hardware. Any help would be appreciated.

110014 Brent Lamb
via Internet

The following questions are related to the same topic.

I am looking for a chip set, Tx and Rx, used in multi-channel remote control. I need up to six functions in a pulse train using pulse width modulation (positive pulse).

Also, any information would be appreciated on using RC servo electronics to power an auxiliary motor. What type of motor, and what are

ANSWERS TO #80014 - AUG. 2000

I have a Rustrak model 288 DC chart recorder that I would like to use to measure a variety of DC input voltages and also measure 105-125 VAC.

#1 There are at least two simple ways you can go about this. Figure 1 shows a wall adapter that outputs 3 volts direct current at 100 milliamps. Since this is an unregulated supply, the output will follow (be proportional to) the AC input. The dangerous 105-120 VAC wall voltage is reduced to a safe 3 volts. The 30-ohm resistor provides a time constant for following a slowly varying AC input.

If you want to reduce the amount of power consumed, a slightly more complicated approach is shown in Figure 2. Here you can vary the time constant by changing the resistor and capacitor that are in parallel. (Note that an AC adapter is now being used.)

Surplus Traders (advertises in Nuts & Volts) has these wall adapters. The 3VDC/100mA is 75 cents. Web **www.73.com/w**, phone **514-739-9328**.

Gus Calabrese
via Internet

#2 If you use a full wave bridge rectifier and some resistors as divider networks with a rotary switch, you can make a pretty useful recorder.

You can either use the rectifier before or after the resistors. If you use the rectifier before the resistors, it must be rated for the maximum voltage you intend to apply, but if used after the resistors, it can be pretty low. I think I would use it before.

The beauty of using a rectifier in the circuit all the time is that you can measure AC, DC, and reversed DC, and the rectifier will always present a DC signal to the chart. You should use a capacitor after the rectifier to smooth it out. The big disadvantage of using the rectifier is that you have to overcome about 1.2 volts of drop in the diodes before you see a signal. If you are measuring a low DC voltage, you could switch out the rectifier, and if it is a low voltage AC signal, you could feed a transformer to boost the voltage before applying it to the rectifier.

While it is possible to calculate/calibrate the recorder by knowing the resistance/impedance of the meter circuits, I think I would set up a variable resistor as a voltage divider and compare meter readings with a known good VOM. Just make sure you have some minimum resistance in the circuit all the time, so you do not short out your input signal, especially line voltages.

Once you have a decent reading on the recorder, you can disconnect the variable resistor and measure the legs of it to make a fixed resistor network.

Assuming the recorder is linear, 1.5 volts with 2,200 ohms at 60% reading means the full scale current is about 1.1 mA, calculated with Ohm's Law, which roughly corresponds to your 1.0 mA label. I strongly suggest you put a 1 mA or slightly larger fuse in the meter circuit!

If 2.5 volts DC is about what is necessary to drive the recorder full scale, then a full wave bridge rectifier connected to 125 VAC and then fed to either a series resistance of about 200K (maybe a little smaller, but play it safe), or a resistor divider (roughly 8K and 1K) into the 2,200 series resistor should get you to measure line voltages.

You could use step-down transformers for large AC voltages before feeding a bridge, but that adds a lot of weight and expense. Most meters simply use resistor dividers or series resistors, along with a diode and a cap.

Joe Heck
Wrentham, MA

#3 The Rustrak Model 288 is a palm-sized chart recorder. It uses a small synchronous motor to drive the chart and a D'Arsonval type meter to indicate input values of current. As the motor turns the chart drive, it periodically activates a bar which snaps the meter indicator against the chart surface making a mark. In this way, the meter input current is sampled and recorded.

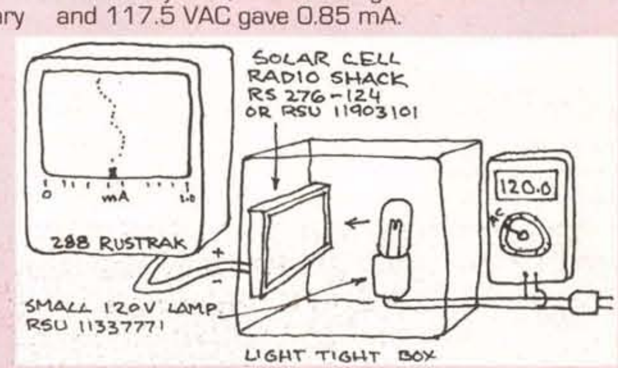
It is easy to record AC voltage values by first changing them to DC with a bridge rectifier, and then using a voltage divider to apply the proper range of current to the meter.

The test and measure chapter of the *ARRL Handbook for Radio Amateurs* has a good discussion of how this can be done along with the significance of peak, average, and true RMS measurements.

One simple and safe method that I have used with my 288 recorder isolates the AC line from the recorder and protects it from potentially damaging line surges. Connect a small solar cell like a RadioShack RS 276-124 to the meter observing the proper polarity. Next, illuminate the cell with a small 120-volt incandescent lamp — the smaller the better as you will not need much light. Put the lamp and solar cell in a light tight box and adjust the distance between the two to give midrange deflection on your recorder.

You might need to put tape over part of the solar cell if you get too much deflection. To calibrate, measure the AC voltage on the lamp and note the associated recorder pointer deflection. It is easy to resolve variations as small as 3 volts.

On my 288, 114.6 VAC gave 0.8 mA deflection and 117.5 VAC gave 0.85 mA.



John Mills
Ben Lomond, CA

ANSWERS TO #9001 - SEPT. 2000

Does anyone know of a circuit I can build, that will allow me to determine the specific percentage of pure silver dissolved in distilled water.

#1 Measuring the colloidal silver content is an interesting problem. You also didn't mention the concentration range or accuracy requirements, and I do not know how they do the measurement in practice. Here are some ideas for dilute solutions.

The best approach is to measure the density, AKA specific gravity. Silver is much denser than water, so you should get a sensitive measurement with good accuracy. The direct method is to weigh a known volume of solution and then calculate the percentage of silver.

A simpler technique is to mimic the hydrometer — the device used for measuring the specific gravity of battery acid. The battery tester measures the volume of fluid required to float a known weight. The float maximizes its sensitivity by making the volume measurement at a thin part of the float. Thermometers use a similar trick.

A quick and dirty indication might use the Tyndall effect. Colloids scatter light, and the amount of scattered light would depend on the colloid concentration. Unfortunately, the scattering depends on the wavelength and the particle size, so it would not give a quantitative measurement, unless several wavelengths were used. That may not be a problem if the interest is process control rather than quantitative measurement.

The particle size is probably too small to use eddy current losses. A distilled water and silver colloid should not conduct, so measuring the water conductivity would not work. Measuring the dielectric constant (capacitance of a test volume) of the solution might work, but two effects might cancel each other out. Water has a high relative dielectric constant (about 80); diluting the water with silver should lower the dielectric constant. Unfortunately, silver is a conductor, and it may decrease the effective distance between the test capacitor plates by about the same amount. In any event, measuring small capacitances is technically challenging.

Gerald Roylance
Mountain View, CA

#2 The circuit that you want is simple. The math conversion is the problem. Any standard ohmmeter or PH meter will measure the colloidal differences in a solution, giving you a electrical reading. But its these numbers that have to be converted into a percentage ratio, and that's where the problem arises.

Almost any standard electrical pick up in the form of two metal probes or plates attached to any standard ohmmeter, voltmeter, ammeter, or PH meter will give you a value or number that you can read. Converting these numbers from the scale into a usable "percentage of soluble metal" in that suspension of a liquid, is the problem.

Soluble metal and its excess ions will conduct and give any electrical meter a reading via a probe.

The only way to convert these numbers into a usable format — from the amateur point of view — is to experiment using standard charts for reference.

You have to start by saturating a liquid beyond its known maximum saturation value and then allow it to settle for several days.

Using one of the types of electrical probes — one that has a preset or fixed distance — measure the value and chart it as being "the maximum value."

Keep in mind to only measure the top or upper half of the solution keeping away from any slurry.

Then start with a very small and given measured amount of the same metal, a minimal amount equal to a arbitrary starting point, and at the first point of reaction in the solution, label this as being near the zero point.

Again, the problem here is that what you read thereafter may not be linear, and so charting of the numbers is more critical or important than the actual electrical method or probe.

Most electro-chemical measuring tools compensate for these non-linear values via a non-linear meter scale marking and other methods. Also, keep in mind the solution's temperature, because this can alter the solubility of most materials.

Another factor is getting the metal to dissolve, and this is where a stirring table comes in handy.

Metal is slow to dissolve and may take days or weeks to accomplish, depending on purity, mesh, and what impurities it possesses to begin with such as salts, acidity, hardness, and alkalinity. Unless you stir it day and night in some cases, you won't know for sure if it is at its maximum saturation point.

Below are two web sites that have some very interesting studies and results of a government survey, as well as some tables and charts that might be helpful in your quest.

http://geology.cr.usgs.gov/pub/open-file-reports/ofr-97-0151/html/stpmw04.shtml#Water_and_Colloids

http://geology.cr.usgs.gov/pub/open-file-reports/ofr-97-0151/html/stpmw06.shtml

Chris
Bieber, CA

possible sources for this motor?

Alternatively, does anyone have a circuit that will take the error voltage from the servo electronics and convert it to reversible drive signals to a motor, AC or DC?

110015 **Dan Paulson**
Bellevue, NE

I have been trying to find a low(er) cost video combiner which will take video from two video cameras (maybe three or four), and allow the combined video to be recorded on one VHF VCR. The format of preference would be top half video source one and bottom half, video source two.

Audio is of no concern as it would be input via the mono audio-in jack on the VCR.

Is there an enterprising individual willing to tackle this problem?

110016 **Dave Lazok**
via Internet

ANSWERS

ANSWER TO #10009 - OCT. 2000

Does anyone have an idea for a circuit to build an inexpensive satellite finder to work on C-band and Direct TV types of equipment?

Emerson makes a cheap DSS (Digital Satellite System) signal strength meter (model #ESF340).

I've seen this unit advertised for around $40.00 at www.heartlandamerica.com (search on "satellite"). It's small (4.5" x 2.5" x 1.5"), portable, and easy to connect and disconnect in the field.

Brandon
via Internet

ANSWER TO #9007 - SEPT. 2000

Some time back, I bought an Apple "clone." It's a "PowerBase 180," 1.2GIG HD, 8X CD-ROM, 32 meg of RAM.

The system didn't come with any manuals or software (i.e., CD, floppies, etc.). It has an IDE HD, with a SCSI CD-ROM. I could live without the TMs probably, but I really need the system disk.

Your PowerBase 180 will run with the standard Macintosh OS CD.

I'm not sure which version came with your computer, but there are a variety of ways to obtain a system CD.

ANSWERS TO #10008 - OCT. 2000

Does someone know where I can obtain a stereo IC part number STK2028?

#1 Try either of the following: **B&B Electronics, www.bbwelectronics.com/RCA-SK.htm, 1-800-749-1710.**

Suburban Electronic Wholesalers, 1-800-341-5353, www.suburban-elect.com.

The STK2028 has been discontinued, so if you find one, don't let it get away!

Phil Shewmaker
Louisville, KY

#2 Look for the STK2028 at one of the following retailers:

Suburban Electronic Wholesalers
1-800-341-5353
www.suburban-elect.com

Union Electronic Distributors
1-800-648-6657
www.unionel.com

MCM Electronics
1-800-543-4330
www.i-mcm.com

Dalbani
1-800-325-2264
www.dalbani.com

BTW, the STK2028II has more pins, so it won't work as a drop-in replacement. However, they should have the same function. With a data sheet for each, an adaptation may be feasible.

Amos Bieler
via Internet

ANSWERS TO #9003 - SEPT. 2000

I have a medium-sized satellite dish. I would like to make a parabolic microphone out of it. I need plans and information on what kind of microphone and amps to use?

#1 One approach for the electronics for a parabolic microphone is to use a portable tape recorder that has both microphone and earphone inputs (jacks).

Use a microphone that is compatible with the recorder and mount it at the focus of the satellite dish where the receiving RF detector was.

The sound falling on the dish will focus at the same point that the RF energy did.

The microphone has to face the dish to pick up the reflected and focused sound waves.

You need a tape recorder that allows the earphone output to be used in monitoring what you record.

It might increase the sensitivity if you were to incorporate a way to move the microphone back and forth along the axis of the dish so as to focus it.

By using a portable tape recorder you can monitor the sound as you move the dish. You can also make a record of the sounds picked up.

Jim Schmidt
Deer Lodge, MT

#2 There aren't really any special technical needs for a basic parabolic microphone.

The basic procedure is this: **1.** Find a microphone/amp/speaker setup that works for you. **2.** Remove the antenna from its bracket on the dish. **3.** Attach the microphone to the dish so that the end of the mic is where the antenna used to be.

Some words of precaution: Since the parabolic shape of the dish functions as an amplifier, already loud sounds can get loud enough to hurt your ears.

If you must use headphones (like in the movies), either wear them so they aren't completely covering your ears. Be ready to turn down the volume knob or wear shooter's earplugs.

Amos Bieler
Springfield, MO

ANSWERS TO #10006 - OCT. 2000

I have a system that does not have any BIOS settings to allow me to boot without an attached keyboard or to continue boot after errors, etc. I need a way of "fooling" the system into thinking that a keyboard is attached so it will boot.

#1 A Phantom keyboard/mouse adapter is available at **Vetra Systems Corporation**. Phone **631-434-3185**, **www.vetra.com**. It allows any PC to boot without a keyboard attached.

Thomas B.
Folsom, CA

#2 Black Box, www.blackbox.com, sells the "Ghost Emulator" that plugs into the keyboard and allows the computer to boot and run.

Tim Godfrey
via Internet

Mac OS 7.5.5 is downloadable free from www.apple.com.

OS versions from 8.5 to the current 9.0.4 are not certified to run on clones, but are reported to work well for many.

You can buy Mac OS 9 anywhere that carries Macintosh software. Older versions can be purchased from used computer dealers such as **Shreve Systems www.shrevesystems.com**, who happens to be a *Nuts & Volts* advertiser.

Older versions of the Mac OS did not have the wide support for third-party CD-ROM drives as current versions.

If you stick with an older version, you might want to also pick up a third-party CD driver package such as the FWB CD-ROM Toolkit, which originally shipped with the PowerBase machines.

Doug Smith
Roscoe, IL

ANSWER TO #10007 - OCT. 2000

Okay, how can I use an Optrex DMC 20434 LCD using a Scenix 28-pin microprocessor? I cannot find any data to help me!

I assume that you can use the Scenix microprocessor, as you have chosen that over other choices, so the problem is how to connect to and communicate with the LCD.

The keys to interfacing a processor to an LCD display are the pinout and the initialization routine. The Optrex DMC series uses the Hitachi controller HD44780 and can be driven in either four or eight-bit mode. Usually, four-bit mode is used to use fewer data lines.

Pin 1 is Vss (Gnd)
Pin 2 is Vcc (+5v)
Pin 4 is RS (Register Select)
Pin 5 is R/W (Write = L)
Pin 6 is E (Enable)
Pins 7-14 are Data 0-7

In normal four-bit operation, Data 4-7, RS, and E are the only signal pins used.

R/W is hard-wired to Gnd.

All commands to the LCD module are done by pulsing E positive (0.3ms minimum) when the desired data is set on the RS and data lines.

The Initialization sequence is:

Poser On
RS low for entire initialization
wait > 15 ms
0011 (pulse E)
wait > 4.1 ms
0011 (pulse E)
wait > 0.1 ms
0011 (pulse E)
0010 (pulse E)
0010 (pulse E)
1000 (pulse E) see line and font options
0000 (pulse E)
1000 (pulse E)
0000 (pulse E)
0001 (pulse E)
0000 (pulse E)
0110 (pulse E)

Writing to the LCD is as follows:

set RS high
set high 4 bits (pulse E)
set low 4 bits (pulse E)
set RS low

For more details including commands to move the cursor, see the Optrex web site at **www.optrex.com/techsupport.stm**.

The manual for the character displays is available in PDF format.

Mike Beaver
Los Altos, CA

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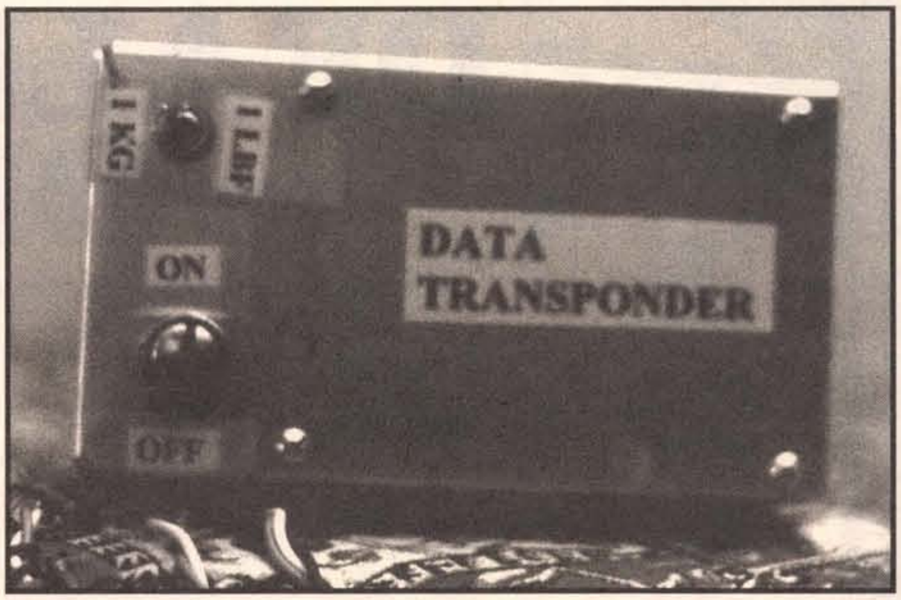
A Data Transponder for Model Rocket Engine Development

by Bob Vun Kannon



I like to make it easy on myself by being absent from explosions. When developing rocket engines from scratch, there is a positive, non-zero probability of an explosion on any given firing. Thus, a device to gather data from the test which allows me to be elsewhere is highly useful.

In developing a rocket engine, it is critical to be able to profile the thrust versus time of the engine. The pressure in the engine is proportional to the thrust. Explosions generally occur when the pressure gets too high. A device which would measure the thrust many times per second and report it to me a safe distance away would solve my allergy to explosions.

The data provided would also allow me to build up a picture of the burn rate of propellants versus pressure. Knowing the geometry of the propellant and the burn rate would allow me to figure the mass flow rate versus time and thus the Specific Impulse (Isp) versus pressure. The device to help me accomplish all this is the data transponder.

The Concept

The concept is fairly simple (see Figure 1). The thrust of the rocket engine is converted to a rather small, analog, differential voltage by the force sensor. The data transponder reads the output of the force sensor and produces a digital report (RS-232) for the RF Transmitter. The RF receiver, located conveniently far away from the actual rocket engine, converts the signal back into RS-232, which is then read through the serial port of the bench top computer and stored on hard disk for later use. Admittedly, the RF link is not necessary if you're willing to string wires all the way to the bench top computer, but my sincere thanks to Dan Ngai, a Field Applications Engineer for Insight Electronics, for suggesting it and making the development kit available.

A block diagram of the data transponder is given in Figure 2. The analog signal from the thrust sensor is differentially received and amplified by an instrumentation amplifier. This produces an analog voltage in the range of 0 to 3.3 volts. The microcontroller used here — an Atmel AT90S1200-12PC — has an onboard analog comparator, which is used to compare the output of the instrumentation amp with the feedback from the R-2R ladder. This, with appropriate software, forms an analog-to-digital converter. The microcontroller puts out an eight-bit number to the R-2R ladder. The output from the ladder is a voltage proportional to the digital number (Vout = Number/256*Vcc*2/3). Thus, by reading the output of the comparator, the processor can successively test the effect of each bit in the field to arrive at the closest approximation of the analog input value. This resulting number is then sent out as a digital stream of eight bits (plus one start bit and one stop bit) to an op-amp, which serves as a level translator from the 5V output of the processor to the levels of RS-232.

The Schematic

There are clearly two main components of the data transponder. These are the instrumentation amplifier and the processor.

An instrumentation amp is a lovely device for converting a low-level signal to more readable levels. Referring to the schematic of Figure 3, the instrumentation amp, U1, is a Burr-Brown instrumentation amplifier. Its voltage gain is set by the resistance it sees between pins 1 and 8 (Gain = 5 + 200K/R). I have indicated a jumper on the schematic to switch between two different gain settings, one pound thrust full scale and 2.2 pounds full scale.

The microcontroller used here, U2, definitely deserves more than a little comment. This is an Atmel 1200, the bottom end of the AVR line of eight-bit microcontrollers. It is a true RISC machine, executing an instruction in only one clock cycle. The version I used is a 12 MHz chip capable of 12 MIPS performance. It is extreme overkill for this job. The architecture of the AVR processor is very likeable. It has 32 general-purpose registers. (It's like having 32 accumulators.)

The R-2R ladder was made of 1% metal film resistors which I hand selected to 0.5%. I tested the accuracy of the ladder with the test program (listed here in the article) and an oscilloscope. A picture of the test waveform can be seen in Figure 4. Note the linearity of the waveform.

As I did not have a convenient crystal on hand for this job, I used an old 1 MHz crystal oscillator from my junk bin. Even slowed down to 1 MHz, the processor is loafing on this job.

The choice of the 741 op-amp for U4 was purely a matter of junk-bin pragmatism. It did force me to slow the serial data rate down to 2400 baud from the 9600 baud I originally intended. If I were designing a PCB for this, I would surely use a higher crystal frequency, and a faster op-amp or an actual level translator, like a MAX-232. The microprocessor

SYSTEM BLOCK DIAGRAM

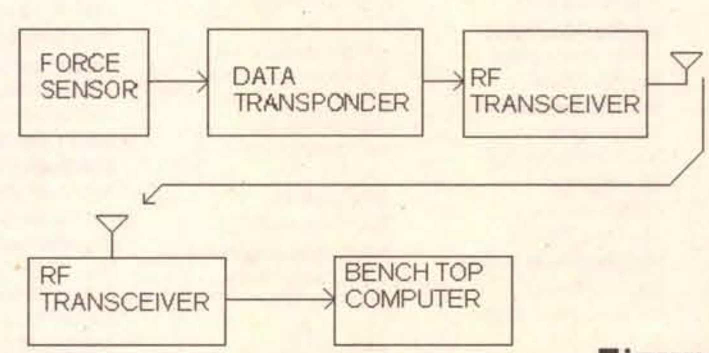


Figure 1

DATA TRANSPONDER BLOCK DIAGRAM

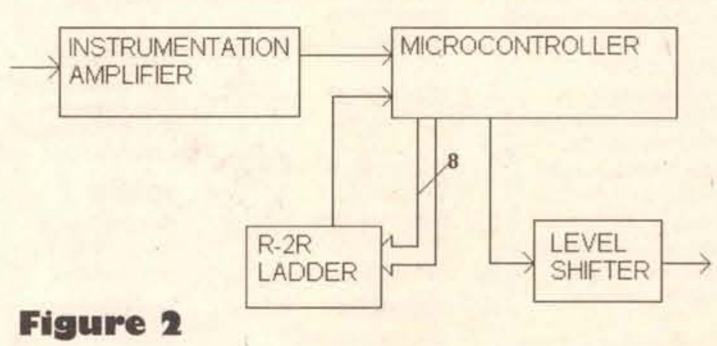


Figure 2

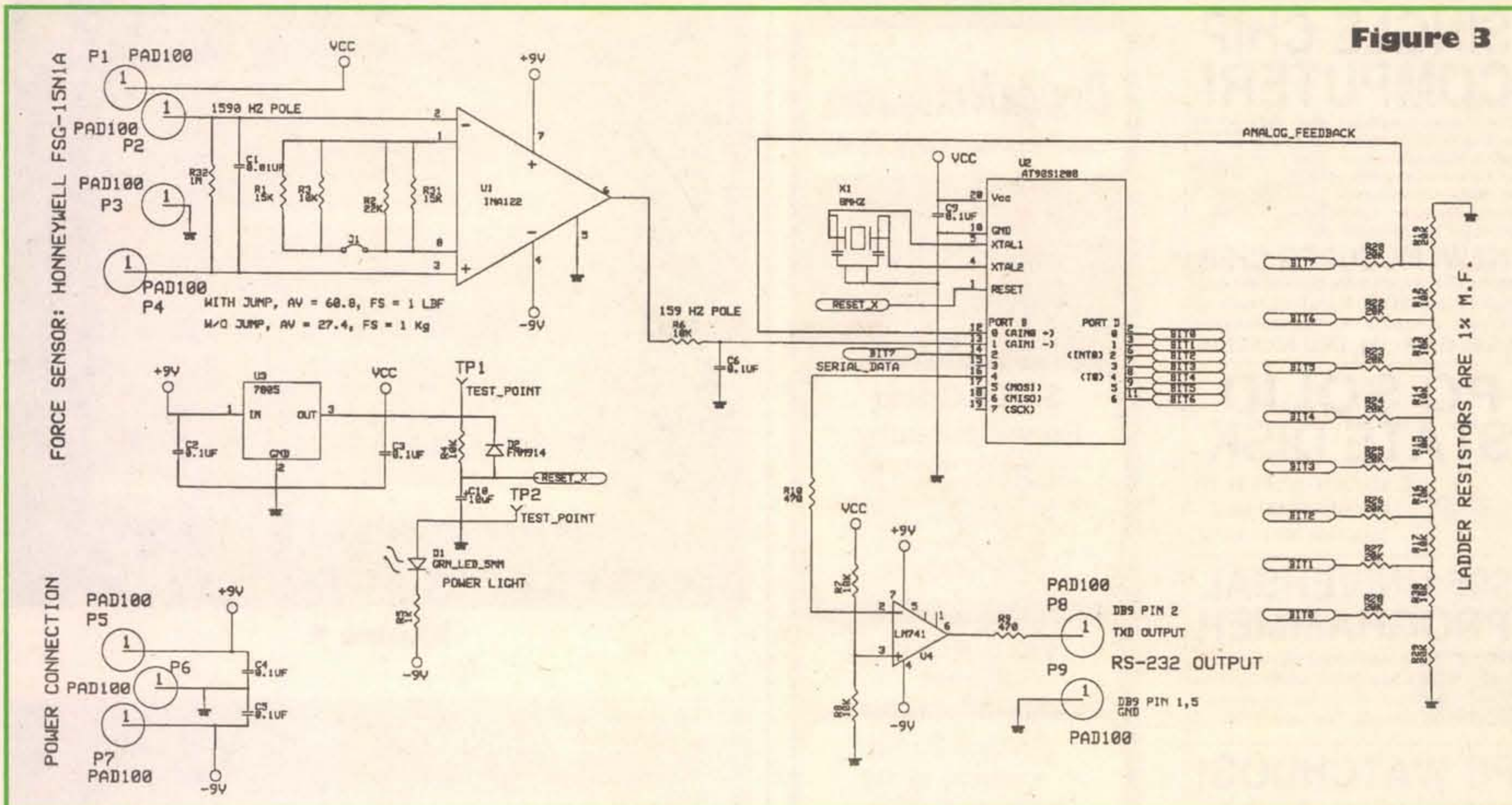


Figure 3

would still be taking life easy at 19,200 baud.

The Software

It actually only took five minutes to write the source code for the data transponder. That's because I wrote it in AVR Basic, This is a language I developed for the Atmel AVR microcontrollers and it is heavily optimized for the AVR architecture. The AVR Basic compiler compiles the AVR Basic source code into assembler source code, which is commented with the AVR Basic statements. I then used the free assembler provided by Atmel on their website (www.atmel.com) to produce the object code for the processor. The AVR Basic compiler is rather good, even if I say so. It averages about 2.2 assembler lines per line of AVR Basic source code when doing eight-bit tasks. Thus, with a 12 MHz processor, I can execute over five million lines of AVR Basic source code per second.

The source code (which is availabl on the *Nuts & Volts* website at www.nutsvolts.com) for the data transponder deserves only a little comment.

"DEVICE" informs the compiler of the processor in use.

"MHZ" informs the compiler of the processor's clock speed (in MHz).

"DIRPORT" sets the direction for each bit in a port (1 is out, 0 in).

"OUTPORT" writes a byte to a port.

"ANALOG" reads the output of the onboard analog comparator into a byte.

"SHIFT" does just that, it shifts a variable with a 0 fill. (Why shouldn't

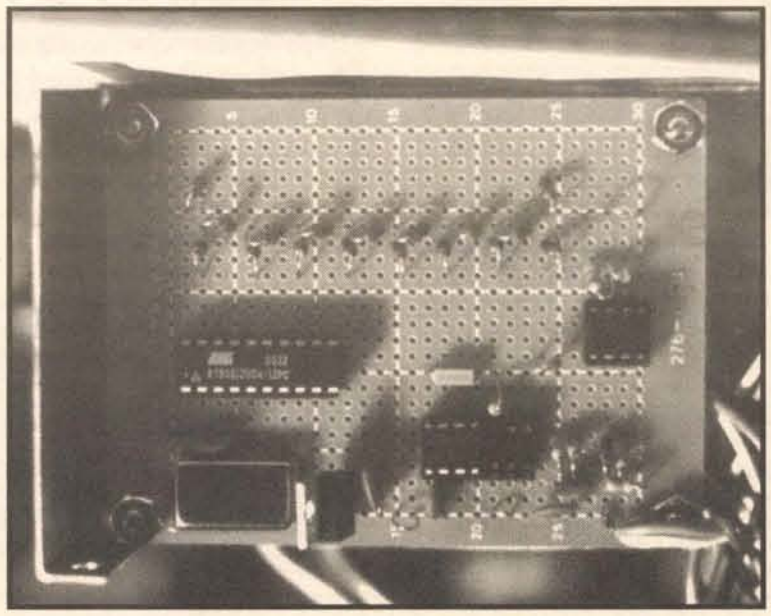


Figure 4

Test Program Source Code

```
DEVICE 1200
  MHZ   1
  REVISION Transponder ramp- 000917.0-rvk

'=====REVISION RECORD==================================
'======================================================

'=====I/O DEFINITIONS==================================
'   D0  OUT  BIT 0 D/A
'   D1  OUT  BIT 1 D/A
'   D2  OUT  BIT 2 D/A
'   D3  OUT  BIT 3 D/A
'   D4  OUT  BIT 4 D/A
'   D5  OUT  BIT 5 D/A
'   D6  OUT  BIT 6 D/A
  DIRPORT D,OUT

'   B0  IN  ANALOG COMPARATOR INPUT
'   B1  IN  ANALOG COMPARATOR INPUT
'   B2  OUT  BIT 7 D/A
'   B3  OUT  SPARE
'   B4  OUT  SERIAL OUTPUT (TXD)
'   B5  IN  MOSI
'   B6  OUT  MISO
'   B7  IN  SCK
  DIRPORT B,&B01011100
  OUTPORT B,&B10100000
'====END I/O DEFINITION=================================


MAIN: DO
    INCR data
    GOSUB OUTDAT
  LOOP

'====BEGIN OUTDAT================================
'=   input: data          =
'=   output: ports D and B,2       =
'================================================
'   STACK 2
OUTDAT: OUTPORT D,data
  IF DATA > &H7F
    SETBIT B,2
  ELSE
    CLRBIT B,2
  END IF
  PAUSE .03
RETURN
'====END OUTDAT==================================
```

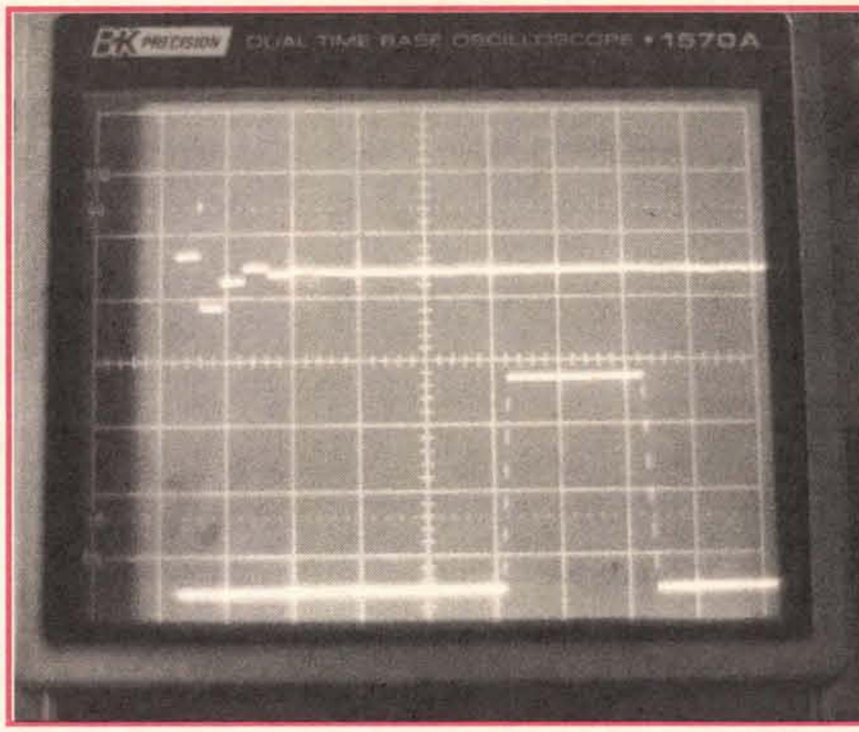


Figure 5

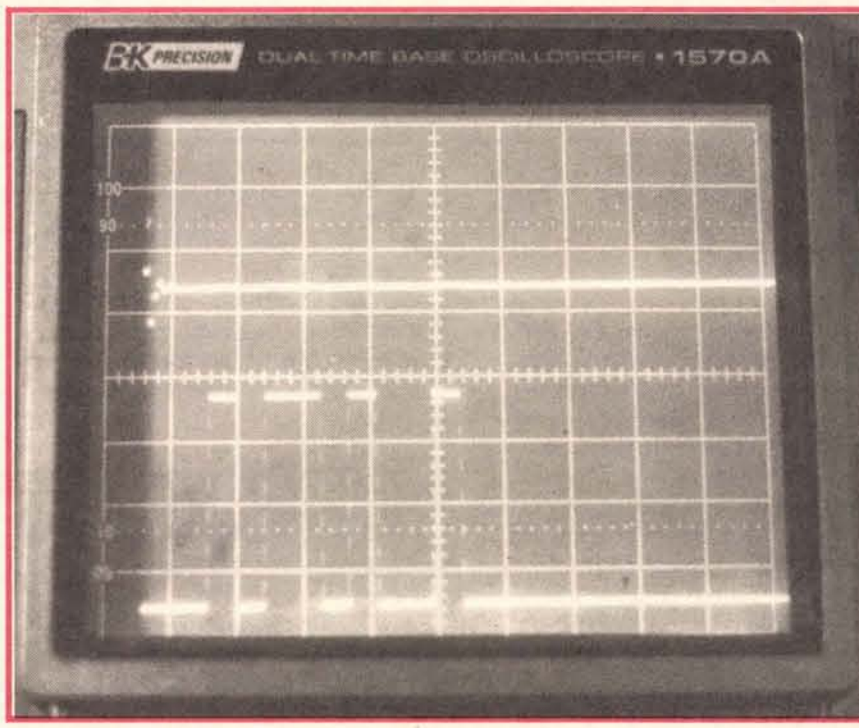


Figure 6

Basic have a SHIFT command?) You specify the direction and number of shifts.

"SEROUT" shifts a byte out serially at the bit-rate specified, through the port and pin specified, prefixing with a start-bit and terminating with a stop bit. (It does its timing by using the eight-bit counter on the processor to control time delays.) This results in an "N81" format for RS-232 (no parity, eight bits, one stop bit).

"PAUSE" simply pauses the processor for the time specified in milliseconds.

"SETBIT" and "CLRBIT" set and clear a specified bit in a port.

Oh yes, the "IF" statement uses the "|" to mean not-equal.

These are a few of the hundred plus statements supported by AVR Basic. If you want a complete list with syntax you can contact me at rvkbob@juno.com. I have not released the compiler yet, but maybe you can talk me into it. See the Source Code.

System Performance

This Data Transponder reads the analog input every 25 milliseconds with eight-bit precision and sends a one-byte report out serially. The actual time to perform the analog-to-digital conversion is 160 microseconds. This could be sped up a lot, but there was no need to do so for this project. Out of the 25 millisecond cycle, the processor spends 0.16 milliseconds converting, four milliseconds transmitting, and the rest of time just killing time. In actual use, the data report is rock solid and very repeatable. The total system noise is much less than 1 LSB.

Two pictures from the oscilloscope show waveforms of interest. In both Figures 5 and 6, the top trace is the output of the R-2R ladder (1V/div.) and the bottom trace is the RS-232 output (5V/div.). In Figure 5, the successive approximation process is clearly visible. The curious looking little spike is due to the fact that the OUTDAT routine outputs the lower seven bits before it outputs the MSB.

In Figure 6, you can just see the A/D conversion on the top trace followed by a data transmission on the bottom trace. The output data swings between approximately +7.5V and -7.5V: the result of the op-amp operating from ±9V batteries.

Programming Hardware

All programming of the microcontroller was performed on an Atmel STK200 development board. This board, with programming software, is generally available from electronics distributors like Insight Electronics and Avnet at a very reasonable price. Alternatively, you could design in on-board programmability, but for your first time out, I recommend the STK 200. Later on, if you can talk me out of a copy of AVR Basic, it includes programming software (for DOS) and instructions for making your own interface cable.

Data-Logging Code

I am including a copy of the code for logging the data on a PC. It is written in Power Basic 3.5 for DOS and can also be run or compiled by Quickbasic 4.5. It will run, from the DOS shell, in Windows 95 and 98 but not from Windows 2000 or NT.

Room for Improvement

The Data Transponder works

```
DEFINT A-Z

        '...RX Datalogger for the Thrust Sled Transponder...

        DEFINT A-Z
'===========revision record===================
'000821.0-rvk  created from rx.bas.
'001001.0-rvk  changed to 2400 baud for slow op-amp.
'==========================================

        cmd$ = UCASE$(COMMAND$)

        IF cmd$ = "" THEN
         cmd$ = "TEST.DAT"
        END IF

        esc$ = CHR$(27)

        OPEN "COM1: 2400,N,8,1,RS,CD0,CS0,DS0" FOR
        RANDOM AS #1

        COLOR 15, 1
        CLS
        LOCATE 2, 1
        PRINT "Receiving from COM1..."
    GOSUB PRMENU
        ON ERROR GOTO errortrap
        DO
         IF EOF(1) = 0 THEN
          A$ = INPUT$(1, 1)
          GOSUB prmsg
         END IF
         k$ = UCASE$(INKEY$)
         IF k$ <> "" THEN
          SELECT CASE k$
           CASE esc$
                EXIT DO
           CASE "L"
                LOCATE 20, 1
                PRINT "Logging to "; cmd$
                OPEN cmd$ FOR OUTPUT AS #3
                logflag% = -1
                PRINT #3, DATE$; " "; TIME$
           CASE "S"
                LOCATE 20, 1
                PRINT "                  ";
                LOCATE 20, 1
                PRINT "Not logging.";
                IF logflag% THEN
                 CLOSE #3
                 logflag% = 0
                END IF
          END SELECT
         END IF
        LOOP
        LOCATE 2, 1
        PRINT "                  ";
        LOCATE 2, 1
        PRINT "END of transmission."
        LOCATE 22, 1
        END

errortrap:
        A$ = ""
        RESUME NEXT

PRMENU:
        COLOR 15, 1
        LOCATE 20, 1
        PRINT "Not logging.";
        LOCATE 21, 1
        PRINT "Begin ";
        COLOR 14, 1
        PRINT "L";
        COLOR 15, 1
        PRINT "ogging, ";
        COLOR 14, 1
        PRINT "S";
        COLOR 15, 1
        PRINT "top logging, ";
        COLOR 14, 1
        PRINT "ESC";
        COLOR 15, 1
        PRINT "=exit."
RETURN

prmsg:
        FOR i = 1 TO LEN(A$)
         t$ = MID$(A$, i, 1)
         LOCATE 5, 1
         s$ = MID$(STR$(ASC(t$)), 2)
         WHILE LEN(s$) < 3
          s$ = "0" + s$
         WEND
         h$ = HEX$(ASC(t$))
         WHILE LEN(h$) < 2
          h$ = "0" + h$
         WEND
         PRINT s$; " ["; h$; "] "; TIME$
         IF logflag% THEN
          PRINT #3, s$; " "; TIME$
         END IF
        NEXT
RETURN
```

Data-Logging Code

fine for its intended purpose. It could be improved and expanded to handle more input channels by placing a differential MUX before the instrumentation amp and addressing the MUX with spare outputs from the processor. Obviously, the format of the output data would need to be changed to identify the channel number with each datum.

The R-2R ladder could be replaced with a 12-bit or higher A/D converter. An A/D with a serial interface would be desirable here. Or, you could switch to a different processor, like the Atmel 4433 which has a 10-bit A/D on board. Again, this change in resolution would require a change in output data format.

The most likely improvement that I will put into the transponder is to remove the PAUSE statement from the main loop and decrease C6 to 0.01uF. This will increase the sampling rate from 40 samples per second to over 220 samples per second. The increased sample rate will allow better numerical integration in post-processing.

I look forward to a pleasant development cycle of rocket engines with my complete absence from explosions, thanks to the Data Transponder.

Special Thanks

I would like to express my thanks for the support of Bob Davy, of Insight Electronics, in supplying the INA122 and the AT90S1200 for the project. Sincere thanks also go to Steve Bourque of Avnet Marshall who supplied the Honeywell force sensor. **NV**

Parts List for the Transponder

REF	VALUE	SOURCE
C1	0.01uF	Digi-Key (www.digikey.com)
C2-5	0.1uF	Digi-Key
C9	0.1uF	Digi-Key
C10	10uF 10V	Digi-Key
D1	LED, general	Digi-Key
D2	FMM914 or 1N914	Digi-Key
J1	Switch, SPST	RadioShack (www.radioshack.com)
R1	15K 10% 1/4W	Digi-Key
R2	22K 10% 1/4W	Digi-Key
R3-4	10K 10% 1/4W	Digi-Key
R5	1K 10% 1/4W	Digi-Key
R6-8	10K 10% 1/4W	Digi-Key
R9-10	470 10% 1/4W	Digi-Key
R12-17	10K 1% 1/4W	Digi-Key
R19-29	20K 1% 1/4W	Digi-Key
R30	10K 1% 1/4W	Digi-Key
R31	15K 10% 1/4W	Digi-Key
R32	1M 10% 1/4W	Digi-Key
U1	INA122	Insight Electronics (www.insight-electronics.com)
U2	AT90S1200-4PC	Insight Electronics, Avnet Marshall Electronics (www.avnetmarshall.com), Pioneer Sterling (www.ied.pios.com)
U3	LM7805	Digi-Key
U4	LM741	RadioShack
X1	Crystal, 8 MHz	Digi-Key
PCB, gen. purpose		RadioShack
Honeywell force Sensor FSG15N1A		Avnet Marshall
RFM RF development Kit, DR 1200-DK		Insight Electronics

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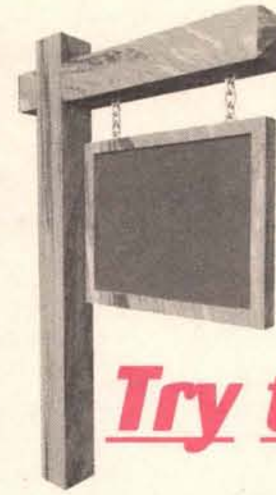

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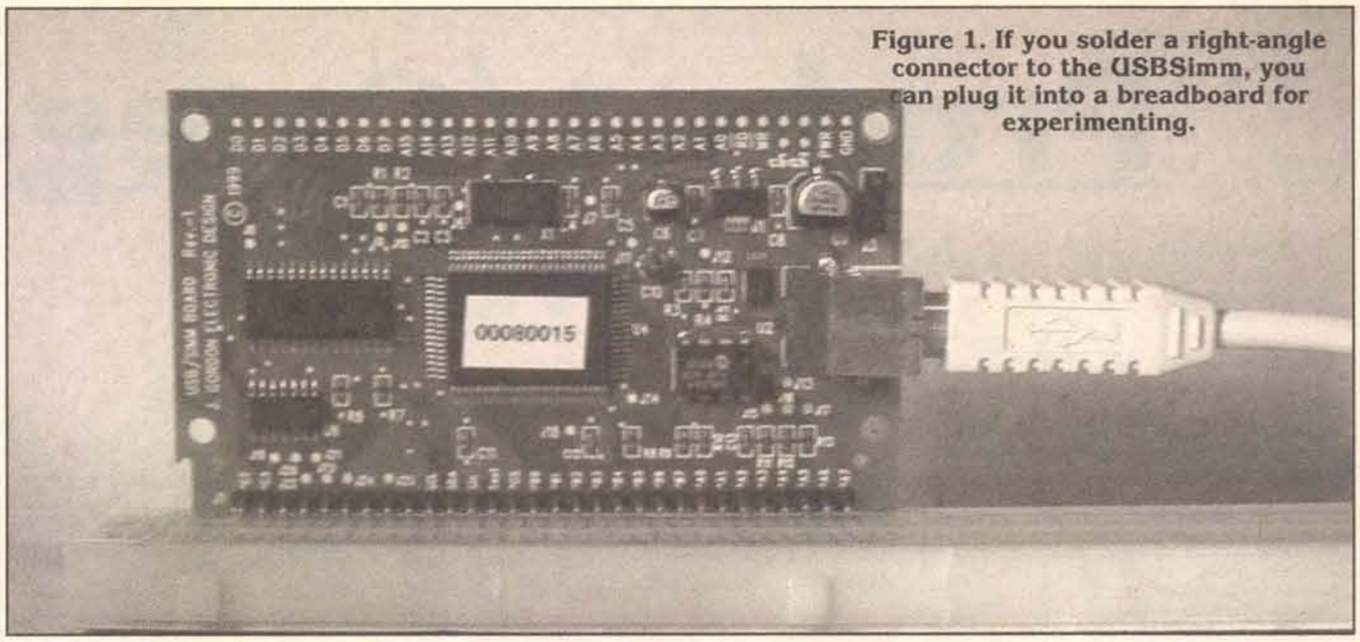

Figure 1. If you solder a right-angle connector to the USBSimm, you can plug it into a breadboard for experimenting.

USB Quick Start: Using the Universal Serial Bus

Chances are that you have a project in mind that involves controlling outputs or reading inputs from a PC. Maybe you want to read sensors or switches, or control motors or relays. But it's likely that your RS-232 and printer ports are already reserved for other uses. Can you make use of that spare USB port? In this article, I'll show you a quick way to use USB to monitor and control digital signals from a PC.

The key to it all is a small PC board called the USBSimm. The board and its supporting code do the hard parts, including managing the details of the USB communications and even loading program code onto the board for you. This leaves just two things. You design the circuits you want to connect to the USBSimm's two eight-bit ports. Then you can adapt the provided software for use in your own applications to monitor and control the ports.

In short, it's a great way to get started with USB.

About the Board

To understand the USBSimm, you need to know a little about the Universal Serial Bus (USB). For an introduction or refresher, see the USB Essentials sidebar.

The USBSimm is a printed circuit board the size of a business card. The board contains the basic components for a USB device, including a USB-capable microcontroller, additional memory, and connections for adding your own circuits. The board is available from Control Solutions, a division of J. Gordon Electronic Design.

The board's AN2131 microcontroller is a member of Cypress Semiconductor's EZ-USB family. EZ-USBs are compatible with the popular 8051 family. The AN2131 has a USB port and plenty of other resources, including three eight-bit I/O ports and an I2C serial interface.

The chip has eight kilobytes of RAM for program and data storage. An external chip adds another 32 kilobytes. (Why RAM instead of EPROM for program storage? More about that below.)

An eight-kilobyte 24LC64 serial EEPROM can do two things. It can store optional information that can help the PC decide what driver file to load for the chip. And it can also store program code that the chip loads into RAM and runs on power up. The EEPROM uses the I2C interface, which is also available for use by other components.

There's a 3.3V regulator, a jumper to select whether to use the +5V available on the USB cable or your own supply and, of course, a USB connector.

To add your own circuits to the board, you have a couple of choices. Along one end of the board is a row of 30 contacts that connect to the port bits and various other useful locations. Above each of these contacts is a plated-through hole.

The 30 contacts fit a SIMM socket. SIMM stands for Single Inline Memory Module and refers to the small boards that PC motherboards used for expansion RAM a few years back.

SIMM sockets are readily available. A SIMM bus is a printed circuit board with two or more SIMM sockets wired in parallel. Plug the USBSimm into one socket, and your own board or boards into the other(s). And you don't even have to make the boards because Dontronics has inexpensive bare boards and parts kits.

If your needs are simpler, you can skip the SIMM bus and solder directly to the holes on the board. To use the board with a solderless breadboard, solder a right-angle SIP connector to the holes. The USBSimm then plugs in "standing up" on the proto board (Figure 1).

If you want to use the chip's address and data buses to add memory or other components, there's another set of holes along the top of the board for this.

Program Code in RAM?

Now, about the RAM. Most microcontrollers store their program code in ROM, E(E)PROM, or battery-backed RAM, because they need to preserve the contents when power is removed. The EZ-USB can store program code in EEPROM, but the chip also has a unique ability to receive its program code from a PC every time it connects to the bus or the PC boots.

Doing it this way has two big advantages: there's no device programming or erasing to bother with and, to update the code, you just need to store a new file on the PC. A downside is that the board won't do anything if it's not attached to the PC. So for example, if you need a remote data logger that collects data on its own, you need to store the program code in EEPROM.

To understand how storing code in RAM works, you need to understand a little about how Windows learns about the devices on the USB. When a device is plugged into a USB port, or when a PC boots with a device attached, a voltage on the port signals that a device is attached.

When Windows learns of the new device, it

USB Essentials

The Universal Serial Bus (USB) is designed as a replacement for the RS-232, parallel printer, and other ports that have been around since the PC's beginnings. The bus can transfer up to 12 megabits per second, though the data-transfer rate for a single device is always less than this. The speed will increase to a very speedy 480 megabits per second when the new USB 2.0-compliant hardware becomes available.

Features of USB include the ability for multiple devices to share the bus, automatic detecting of devices as they're plugged in and detached from the bus, the ability to use port power (no external supply required), and power conservation. To support these features, each USB device must contain intelligence in the form of a microcontroller.

USB's complexity also means that applications can't read and write directly to a USB port address, as you can do with the PC's parallel port. Instead, Windows (and other operating systems) uses layers of drivers to manage communications. Low-level drivers communicate with the hardware that controls the bus, and device drivers manage communications between the low-level drivers and applications that want to read and write to a device. Windows includes device drivers for some device classes, including the versatile human interface device (HID) class.

For more about USB, my website at www.lvr.com has a USB page with links to articles, chip information, example code, and more.

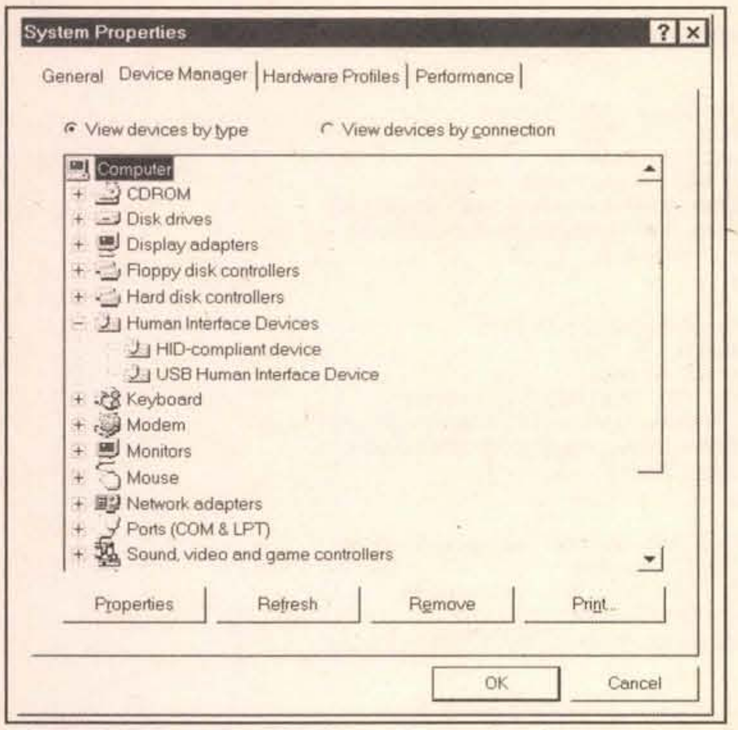

Figure 2. When the USBSimm is running its sample firmware, Windows' Device Manager lists it as a Human Interface Device. Both of the entries under Human Interface Devices belong to the USBSimm.

sends a series of requests to find out more about the device and what device driver to assign to it. The requests that Windows sends are standard ones defined in the USB specification. When the EZ-USB has no stored program code, it communicates using core circuits that know how to respond to the requests.

Windows uses the responses to locate a matching device driver. A special request and an internal switch then enable the driver to load new program code into the device's RAM.

The driver uses a Firmware Download request to send code to the device. The device uses its internal switch to simulate unplugging from and reattaching to the bus. Windows sees the simulated reattachment and thinks there's a new device on the bus. This causes the process of identifying the device to repeat.

This time the chip uses the newly stored code to respond to the requests. Windows assigns a new driver to the device and communications with applications can begin.

Powering Up

What's involved in getting the USBSimm up and running? The nice thing is that you don't have to be a guru of USB knowledge, microcontroller programming, or the intricacies of Windows. You do need to take some special steps to store the files that the device requires. Here's what you need to get started:

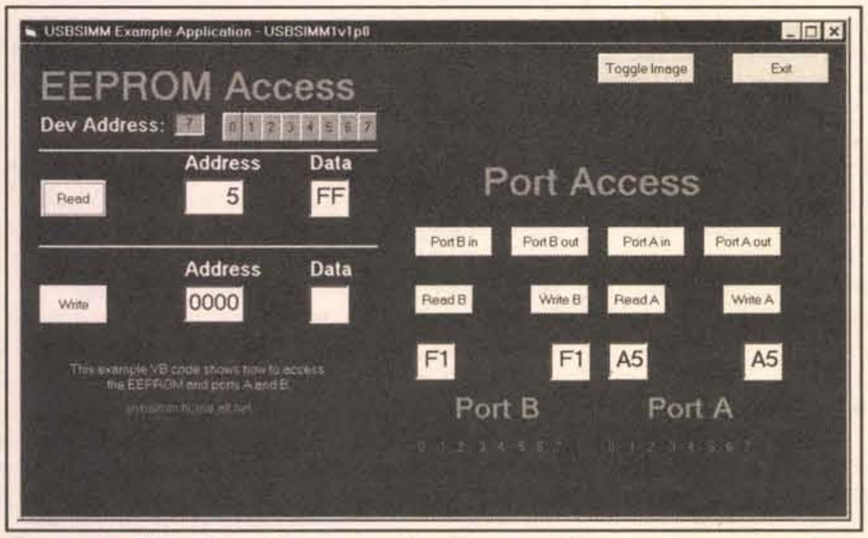

Figure 3. This Visual-Basic application enables you to read and write to the USBSimm's ports and EEPROM.

- A USBSimm.
- A Windows 98 PC with a free USB port either on the PC or a hub.
- A USB A/B cable. These are the standard cables available everywhere, and can be as long as five meters.
- Several files, all available for downloading from the USBSimm's support site. The USBSimm's driver and support file load the USBSimm's program code into the device. An INF file tells Windows which device driver to assign when the device is first plugged in. The example Visual-Basic application and support files show you how to read and write to the board's port pins. You can use the application as a base for writing your own programs.

Sources

USBSimm Support Site
http://usbsimm.home.att.net
User's guide, schematics, ordering info, and more. The USBSimm is $79.95 + $5.00 shipping (US)

Cypress Semiconductor
http://www.cypress.com/usb/fullspeed/ezusb.html
Data sheets, application notes, and example code for the EZ-USB chip.

Dontronics
http://www.dontronics.com/
SimmStick info and boards

Jan Axelson's Lakeview Research
http://www.lvr.com/usb.htm
USBSimm and other example code from my book *USB Complete*.

John Hyde's *USB By Example*
http://www.usb-by-example.com
USBSimm and other example code from John's book *USB Design by Example*. The code provided with the USBSimm is based on John's buttons and lights example.

Here's how to get the USBSimm up and running:

1. Copy the driver files (us1v1p0.sys and us1v1p0.jgd) to the windows\system32\drivers folder in your PC.

2. Copy the INF file (usbsimm.inf) to the windows\inf folder in your PC.

3. On the USBSimm, set the jumper across B and C to enable receiving power from the bus.

4. Attach a USB cable to a free USB port on your PC or an attached hub and plug the other end of the cable into the USBSimm's

```
Private Sub Form_Load()
  'Place this code in the Form_Load routine of your application's startup form.
  'Search for the "USBSIMM1" hardware.
  If OpenUSBdevice("USBSIMM1v1.0") Then
    'If the hardware is found, pass control to the application's main form
    Form1.Show (1)
  End If
End Sub

Private Sub SetPortAToInput()
  'Set all of the lines of Port A to input.
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 73  ' Port A direction command
  OutBuffer(1) = &H0 ' 0 is input
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub

Private Sub SetPortAToOutput()
  'Set all of the lines of Port A to output.
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 73  ' Port A direction command
  OutBuffer(1) = &HFF ' 1 is output
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub

Private Sub SetPortBToInput()
  'Set all of the lines of Port B to input.
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 74  ' Port B direction command
  OutBuffer(1) = &H0 ' 0 is input
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub

Private Sub SetPortBToOutput()
  'Set all of the lines of Port B to output.
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 74  ' Port B direction command
  OutBuffer(1) = &HFF ' 1 is output
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub

Private Function ReadPortA() As Byte
  Dim OutBuffer(10) As Byte
  Dim InBuffer(10) As Byte
  OutBuffer(0) = 69  ' Read Port A command
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
  Call ReadUSBdevice(AddressFor(InBuffer(0)), 6)
  ReadPortA = InBuffer(1)
End Function

Private Function ReadPortB() As Byte
  Dim OutBuffer(10) As Byte
  Dim InBuffer(10) As Byte
  OutBuffer(0) = 70  ' Read Port B command
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
  Call ReadUSBdevice(AddressFor(InBuffer(0)), 6)
  ReadPortB = InBuffer(1)
End Function

Private Sub WriteToPortA(ByteToWrite As Byte)
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 65  ' Write Port A command
  OutBuffer(1) = ByteToWrite
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub

Private Sub WriteToPortB(ByteToWrite As Byte)
  Dim OutBuffer(10) As Byte
  OutBuffer(0) = 66  ' Write Port B command
  OutBuffer(1) = ByteToWrite
  Call WriteUSBdevice(AddressFor(OutBuffer(0)), 6)
End Sub
```

Listing 1. Use these routines with the provided support files to detect the USBSimm and read and write to its ports.

connector.

With no additional help from you, Windows will detect the device and load its driver which, in turn, loads code into the chip. The chip runs the code and simulates removal from and re-attaching to the bus. Windows detects the "new" device and assigns a new driver to it.

You can find out if Windows identified the device correctly by checking Windows' Device Manager. From the PC's Start Menu, click Settings > Control Panel > System > Device Manager. You should see an entry like the one in Figure 2. This tells you that Windows has detected a device in the Human Interface Device (HID) class.

You're now ready to start communicating with your device. The quickest way to see if everything is working is to load and run the sample Visual-Basic application (Figure 3). Click buttons to configure ports A and B as input or output. For outputs, you can enter a value in a text box then click a button to write it to the port. To verify, you can click to read the value or use a voltmeter to read the voltages on the port pins.

For inputs, you can connect switches to the bits or just jumper each bit to +3V or ground, then click to read the values.

The example application also enables you to read and write to the EEPROM. Be careful here, because the EEPROM's contents can be used in identifying the device. (The chip's data sheet has details.)

Using the USBSimm

To use the USBSimm in your own Visual-Basic programs, copy the two .bas files from the example application to your project's folder and use Project > Add Module to add the files to your project. These are the support files required for communicating with the device.

Listing 1 has routines you can use to set a port as input or output and to read and write to the ports. Add these routines to your code and you're ready to go.

Although the USBSimm can communicate at 12 megabits per second, actual data transfer is much slower. In my experiments, my Visual-Basic application was able to write 250 bytes per second and read 31 bytes/second. (The read frequency is a function of the Polling Interval specified in the chip's code, and can be increased if you modify the code.)

This is just the tip of the iceberg as far as what you can do with the USBSimm. The support site (see Sources) has example code and links to tools for writing and loading your own code into the chip. The chip's capabilities and the board's hardware expansion options make the USBSimm versatile enough for all kinds of projects. **NV**

Continued from page 59

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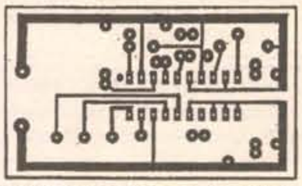

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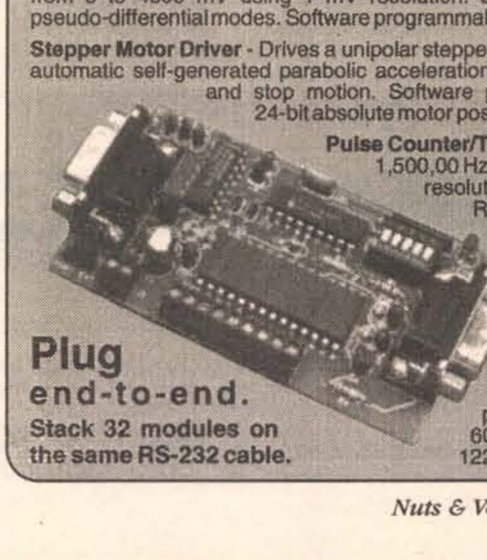

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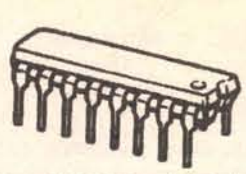

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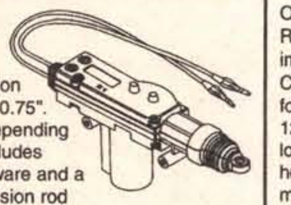

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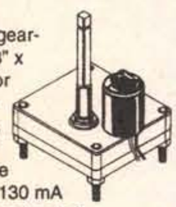

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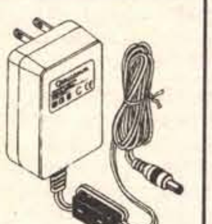

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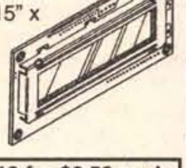

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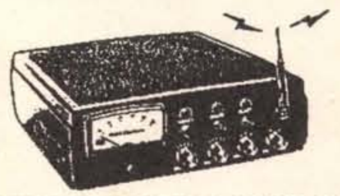

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BUILD THE INCREDIBLE CHRISTMAS TREE DIPSTICK!

by Russ Shumaker

It was Christmas afternoon. The gifts had all been opened, and a substantial brunch had been consumed. The members of the household were all off doing their various things. The resident techie was wandering around the house with his new Dremel® tool, looking for something to grind, buff, drill, polish, or otherwise fold, spindle, or mutilate, when a voice called to him from somewhere in the house.

"Hon, have you checked the tree, lately?"

This was wife code talk for, "Add water to the Christmas tree, *now* please."

This is one of those unspoken chores that the male of the species inherits unknowingly, simply because of his gender; it's kind of like having to take the garbage out, only seasonal.

This process usually involves lying atop a pile of broken toys, while trying to pour a pitcher of water into a hidden tree holder, without spilling most of it on the floor, or onto that nightgown that you haven't yet given to Aunt Agatha. There is a good probability that some of the water will never make it into the tree stand.

The resident techie found the whole process unpleasant, and decided the situation required some thought before launching into it. He built a braunsweiger sandwich, popped a can of inspiration, and went off into the living room to study the problem. He plopped into a chair, assumed the frowned-upon position (feet on the coffee table), and evaluated the problem. The snack was indeed inspirational. He eventually evoked an "Aha!" (and a burp), and trundled off to the workshop, detouring through the kitchen to pick up another cold one. The solution would be electronic, of course.

Description

The device that evolved is rather simple; it consists of a three-conductor probe (dipstick), a remotely mounted blinking LED which gives a visual indication of the low-water level, and a small box containing a two-IC control circuit, a buzzer, and a battery. See Figure 1.

The dipstick activates the circuit. When the full or low-level conductors are shorted by water to the common conductor, the circuit reacts. When the water level is below the low conductor, the LED flashes, until the water is filled enough to short the low conductor. As the water is filled more and contacts the full conductor, a buzzer sounds for about one second, which announces that the tree stand is full. The buzzer then shuts off until the water level drops below the full conductor, and is then refilled. When the water level is between the low and full conductors, which is where it will be most of the time, the LED and buzzer are off. This conserves battery power. When the LED is on, it blinks, which also prolongs battery life.

The LED is on the end of a long cable, which allows it to be mounted onto the end of a tree branch, where it can be seen. It can be secured to the branch with a dark colored twist tie. When the LED is off, it will be semi-invisible. If someone in the family is "artsy-craftsy," the LED can be made part of an ornament; Rudolph's nose, perhaps. If your tree has multicolored blink-

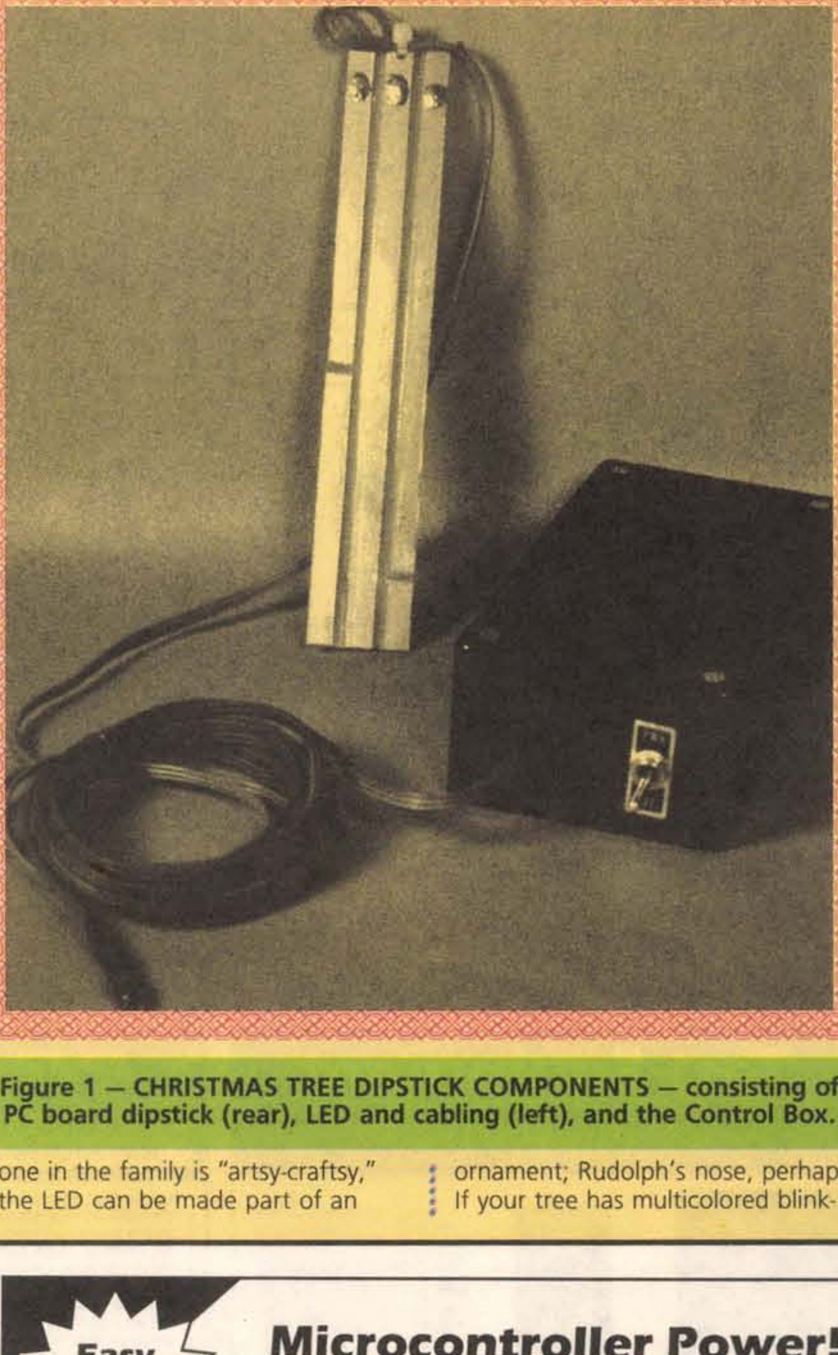


Figure 1 — CHRISTMAS TREE DIPSTICK COMPONENTS — consisting of PC board dipstick (rear), LED and cabling (left), and the Control Box.

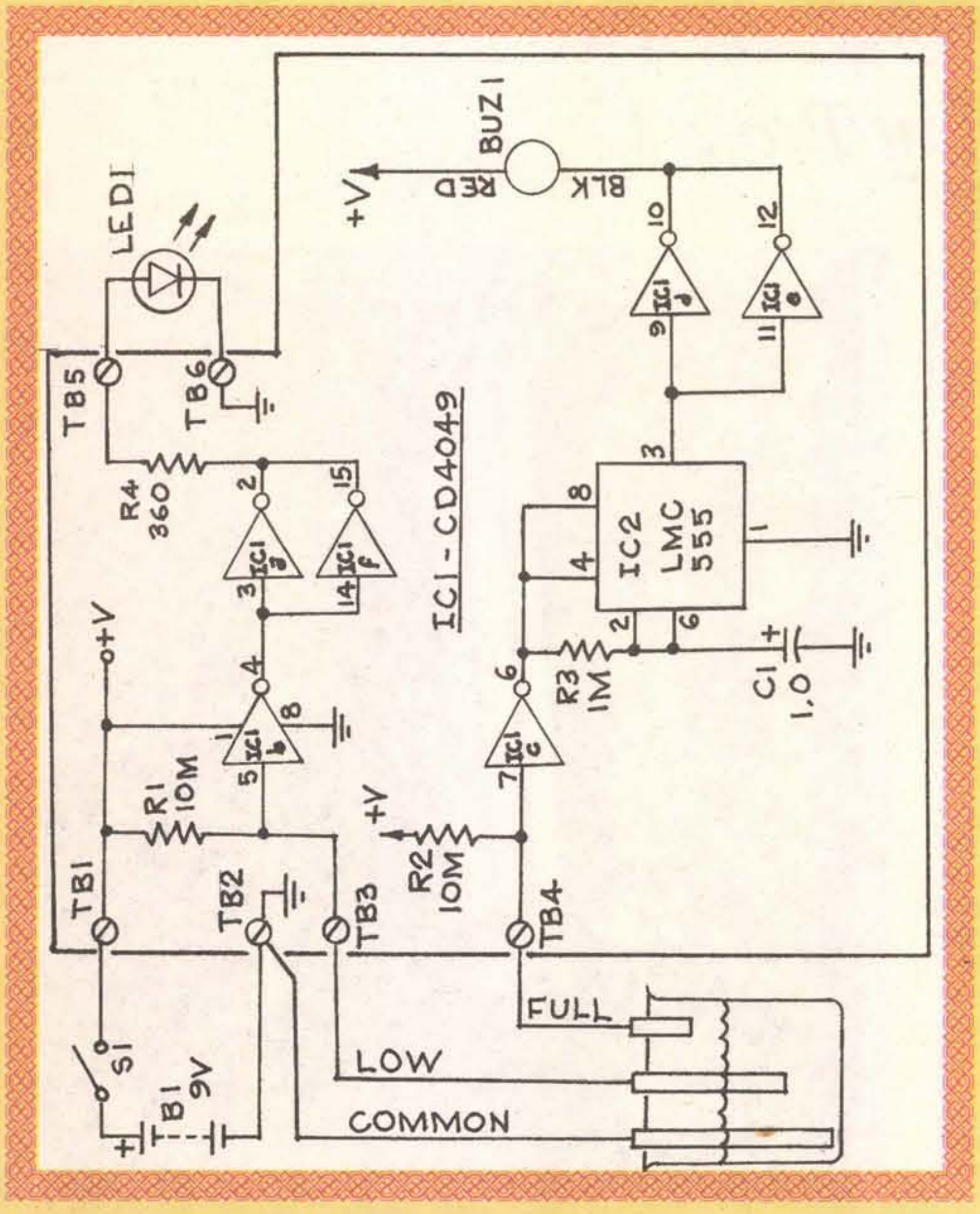


Figure 2 — CHRISTMAS TREE DIPSTICK SCHEMATIC DIAGRAM — Consists of High- and Low-water level probes, circuitry to turn on the low-level LED, and circuitry to activate a one-second buzzer, when the water level reaches full.

ing lights, the LED probably won't be noticed in amongst them. It would then be best to mount the LED away from the tree.

The final piece of equipment required to complete the system isn't electronic, but nevertheless essential. A two-foot long transmission funnel (available at an auto parts store) can be used to fill the tree stand with a minimum of trouble. One only has to listen for the buzzer to tell when the tree base is full. A black or dark green funnel can be nestled between the branches near the backside of the tree, and left there. It will be invisible. A conventional funnel and a piece of plastic tubing will work, as well.

How it Works

The circuitry for the Christmas Tree Dipstick is shown in Figure 2.

The "low" probe is connected to the input of the inverter-buffer gate IC1b (pin 5) through terminal TB3. The "full" probe is connected to the input of the inverter-buffer gate IC1c (pin 7) through TB4. These inputs are held high by pull-up resistors R1 and R2. When the "low" or "full" conductors are shorted to common by the water, these inputs are pulled low.

When the water level is touching the "low" electrode, the LED 1 indicator will be off. When the level falls below the electrode, it will no longer be shorted to common, and the input to gate IC1b (pin 5) will be pulled high by R1. The output of IC1b is then low. This output is inverted by gates IC1a and f, which output a high through resistor R4 and terminal TB5, to turn on LED 1. Gates IC1a and f are paralleled to furnish more output current. Resistor R4 limits the current to LED 1. The LED has a built-in flasher, so it blinks whenever it is energized.

When the tree stand is filled, and reaches the "full" electrode, the input to TB4 is pulled low. This makes the output of gate IC1c high, which also makes pins 4 and 8 of IC2 high. It is applying power to IC2, which is a CMOS 555 timer. Capacitor C1, resistor R3, and IC2 are configured as a power-up reset circuit. When power is applied, it will generate a single pulse output. It will not output again until the power is shut off, and then turned on. Resistor R3 and capacitor C1 determine the pulse length. Time = 1.1 x C1 x R3, and is about one second. Increasing the value of R3 or C1 will increase the buzzer on-time.

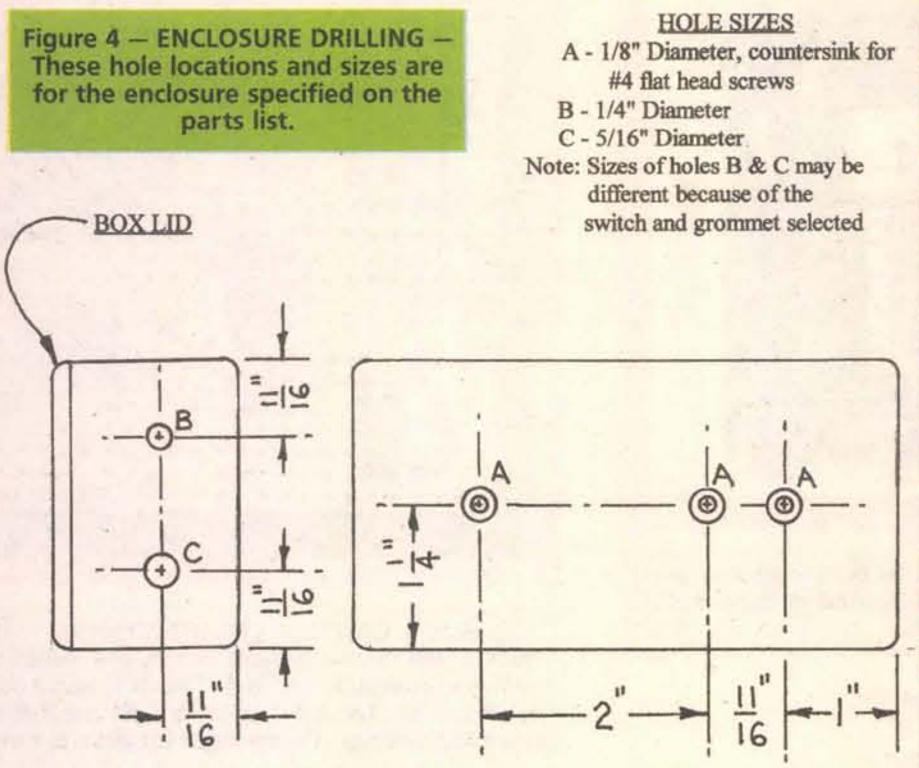
The circuitry operates from a nine-volt battery, which is switched by S1. The voltage supplies the circuit board through terminals TB1 (+) and TB2 (COM).

To recap the operation, when the water level is below the "low" level electrode, LED 1 will flash; when the water is filled, and reaches the "full" electrode, the buzzer sounds for one second. When the water level is between the "low" and "full" electrodes, nothing is activated. IC2 is not powered, so the standby power is extremely low. This increases the battery life considerably.

Construction

See Figure 3. This is fabricated from single-sided PC board material. It can, of course, be etched, but it isn't necessary. The conductor sections can be made by scoring lines with a metal straightedge and a utility knife. The foil between the sections can then be trimmed out with the knife. Separations between conductors can also be done by making shallow cuts with a table saw. The

Figure 4 — ENCLOSURE DRILLING — These hole locations and sizes are for the enclosure specified on the parts list.



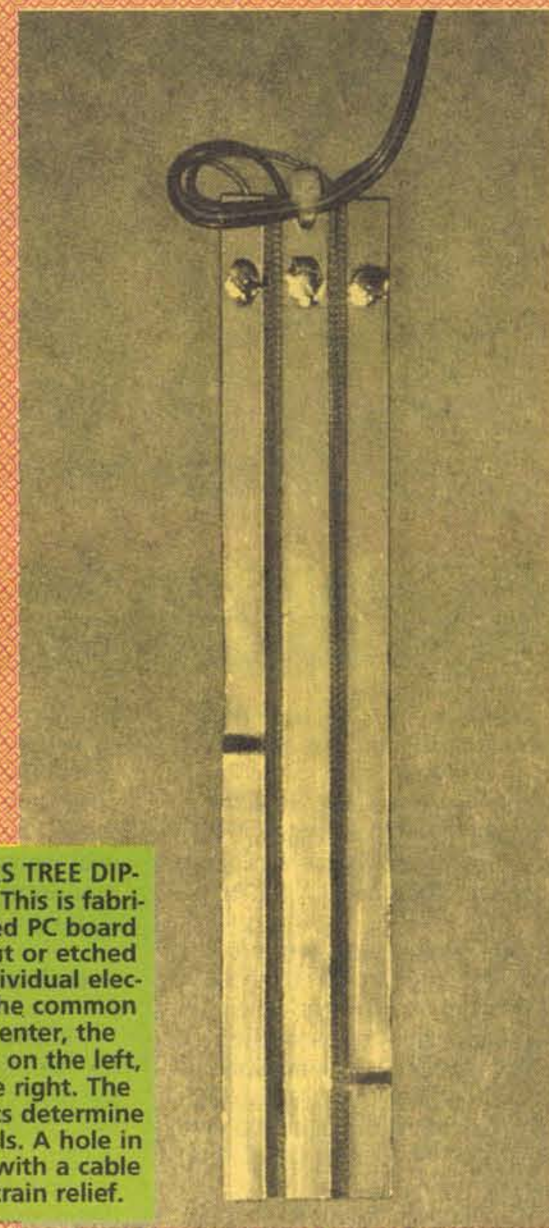


Figure 3 — CHRISTMAS TREE DIPSTICK ELECTRODES — This is fabricated from single-sided PC board material. The foil is cut or etched away to make the individual electrodes. It is 1" x 6". The common electrode is in the center, the high-level electrode is on the left, and the low is on the right. The two horizontal foil cuts determine the high and low levels. A hole in the top of the board with a cable tie furnishes cable strain relief.

water depth of the tree stand determines the location of the full level foil cut.

The low level turn-on point should be a little above the bottom of the tree, so the tree stand is not quite empty when the low indicator turns on. The prototype unit low level is about 3/4". The full level turn-on should be a little lower than spillover. About 1/2" works.

It is not necessary to use PC board material for the probe. Any conductors attached to a non-conductive carrier will work. Solid bare wire can be attached to a strip of Plexiglas, for instance. A hole was drilled near the top of the dipstick, and the lead-in cable secured with a cable tie, for strain relief.

The lead-in wire can be any small gauge three-conductor cable. The prototype uses a three-conductor strip peeled away from the edge of a ribbon cable.

LED Assembly

The LED was soldered to a small gauge two-conductor cable. The prototype used a piece of 26-gauge intercom cable. The length will be determined by its final location. It should be at least six feet long, so it can be placed at eye level. The LED leads are insulated with shrink tubing.

The cable color should be dark, so it won't be noticed. Be sure to mark the LED polarity at the end of the cable that connects to the control module.

Enclosure

This is not sacred. Almost any enclosure that will hold the parts will do.

The hole sizes and locations are given in Figure 4 for the prototype box. If the battery holder is attached with double-sided foam tape, that hole can be eliminated.

Hole sizes for the switch S1 and the grommet are determined by the components selected.

Control Circuit Module

See Figure 5. Nothing is critical on this assembly. The circuit is simple enough to make with point-to-point wiring. Wire wrap was used for the prototype.

The components were mounted

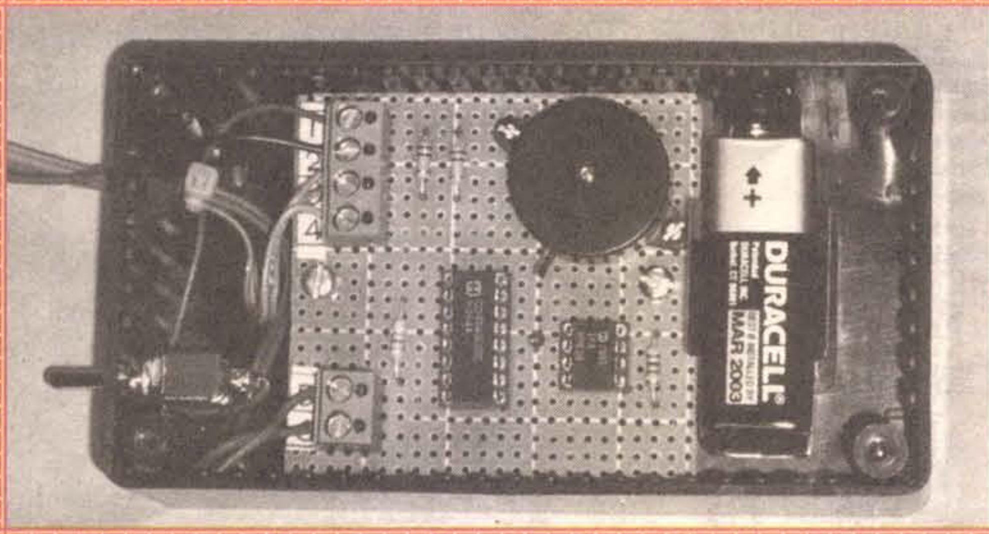


Figure 6 — CONTROL BOX ASSEMBLY — Switch S1 and cables to the electrodes and the LED are shown on the left. The Control Circuit Module is located in the center, and the nine-volt battery is on the right.

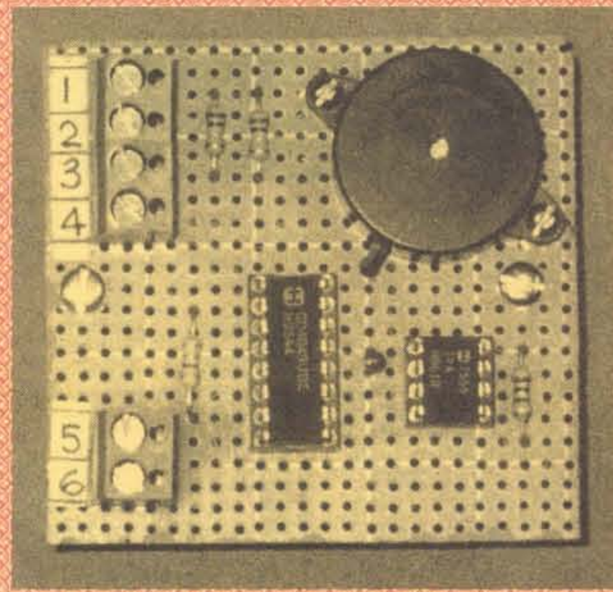


Figure 5 — CONTROL CIRCUIT MODULE — This is assembled on the project board, and holds all the electronic components, including IC1, IC2, and the circular buzzer. The integrated circuits are installed in wire-wrap sockets. Component location is not critical.

on project board rather than perf board. Project board has a solder pad around each hole, so the components can be soldered in place before wiring; it makes assembly easier. The project board was cut to fit the box. That size is 2-1/2" x 2-3/8".

Wire wrap is designed to be used on square pins like those on the wire wrap IC sockets. When wire wrapping onto round leads — such as resistors — tack the wrap with a drop of solder for reliability. The circuit board is mounted on two 5/8" standoffs, to clear the IC socket pins.

The terminal blocks are not absolutely necessary; they do, however, make assembly and troubleshooting a bit easier. All wire lead-ins can, of course, be soldered directly to the board instead.

When routing the cables from the LED and dipstick through the grommet to attach to the control circuit module, add a cable tie to the cables just inside the grommet for strain relief, or wrap the cables around the circuit board standoff once or twice. If you're a Boy Scout wannabe, a clove hitch works great. See Figure 6 for component locations in the box.

Final Test

Install the battery. Put the dipstick in an empty glass, and turn switch S1 on. The LED should blink, indicating low-water level. Slowly fill the glass. When the level reaches the "low" level conductor, the LED should turn off. Continue to fill.

When the water level reaches the "full" conductor, the buzzer should sound for about one second, and shut off. Lift the dipstick so the "full" conductor is out of the water, and then lower again. The buzzer should sound again. Remove the probe from the water. The LED should blink again, until it is reinserted into the water. If the control doesn't react immediately, wait a bit until the water drains off, and the conductors are no longer shorted. Shut the unit off, and install it.

Installation

Before mounting the tree into the tree stand, put two heavy rubber bands around the base of the tree. These hold the dipstick upright. Simply slide the dipstick in behind the rubber bands, after the tree is mounted. A long cable tie, or once around with electrical tape also works.

Be sure that any rubber bands or wrap-arounds are above the maximum water level. Water could possibly get in behind them, short the conductors, and give a false indication. Be sure the bottom of the dipstick is all the way to the bottom of the water reservoir on the tree stand. Mount the LED where it can be seen.

After the holidays, remove the battery to avoid any corrosion that might occur in storage. Christmas tree water can get pretty gunky, so wash the dipstick with soap and water, or alcohol before putting it away.

A fresh battery will easily last through a holiday season

If you are not a live Christmas tree family, don't dismay. You still might find an application for this circuit. It was originally added to an old belt-type humidifier (el cheapo) that doesn't have a low water indicator. The old hunk of junk is still plugging along, and so is its dipstick.

Anyway, Happy Holidays ... with or without the dipstick. **NV**

PARTS LIST FOR THE INCREDIBLE CHRISTMAS TREE DIPSTICK

S1 - DPDT (or DPST) Miniature Toggle Switch (RadioShack No. 275-612, or equivalent).
B1 - Alkaline Battery, 9 volt.
LED1 - Blinking Light-Emitting Diode (RadioShack 276-036, or equivalent).
R1, R2 - Resistor, 100K-ohm, 1/4 Watt, 5% .
R3 - Resistor, 1M-ohm, 1/4 Watt, 5%.
R4 - Resistor, 360-ohm, 1/4 Watt, 5%.
C1 - Capacitor, 1.0-µF, 16-WVDC (minimum) Electrolytic.
IC1 - CD4049 CMOS Inverting Hex Buffer Integrated Circuit.
IC2 - LMC555 CMOS Timer Integrated Circuit.
BUZ1 - Buzzer, Piezo, 3-20 VDC (RadioShack No. 273-059).
TB1 - TB6 - Terminal Block (RadioShack No.276 - 1388, or equivalent). - Optional.

ADDITIONAL PARTS
Project Box (RadioShack No. RSU11907706, or Hammond 1591-CS, or equivalent).
Project Board (RadioShack No. 276-158), cut to size to fit Project Box, above; see text.
Battery Holder (RadioShack No. 270-326, or equivalent).
Battery Snap Connector (RadioShack 270-325, or equivalent).
Misc. - Solder, Wire, Cables, Grommet, Hardware, 8 & 16 pin wire wrap IC Sockets, etc.

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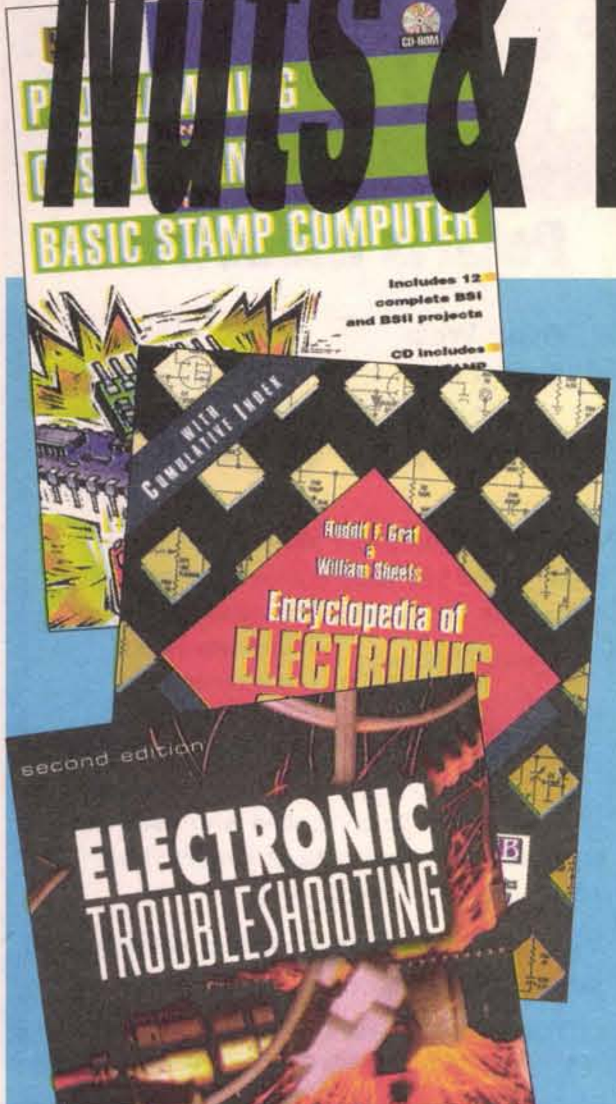

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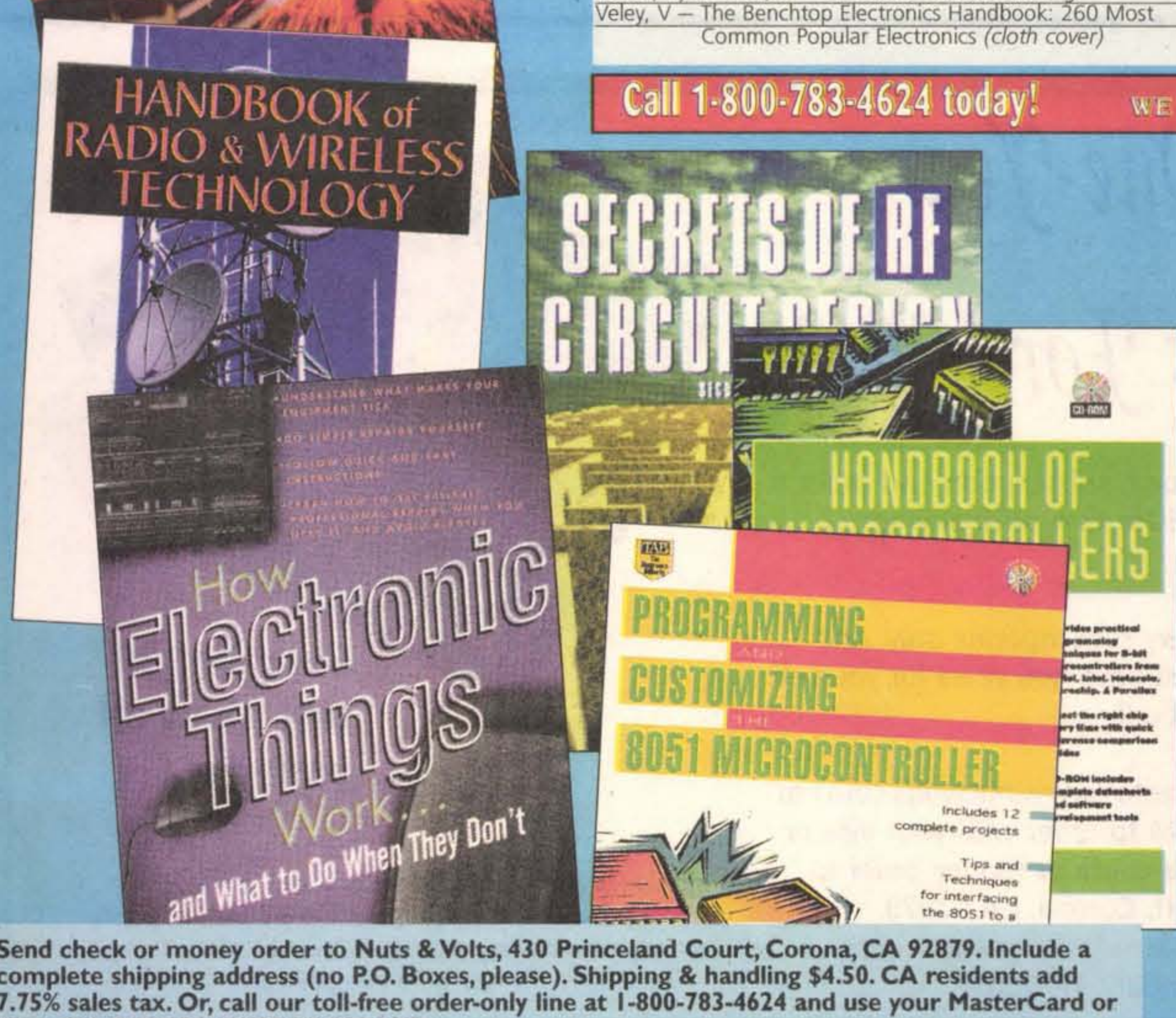

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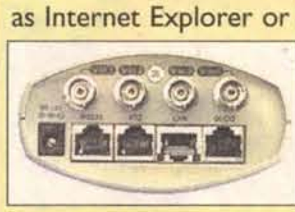

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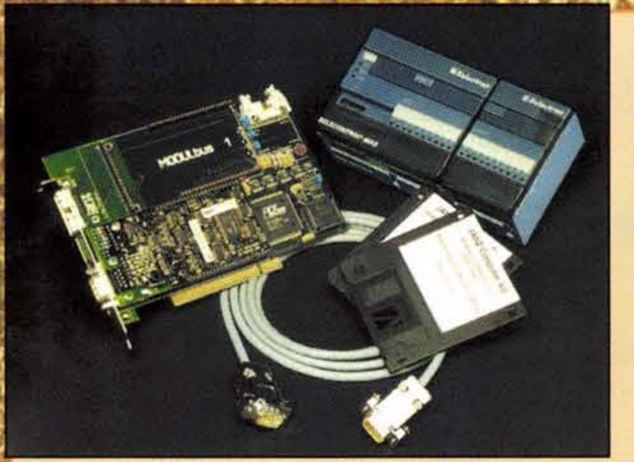

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